ISSN 0829-9560

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by Dale R. Seip
March 1990

BC Ministry of Environment

Wildlife Bulletin No. B-68

ISSN 0829-9560

ECOLOGY OF WOODLAND CARIBOU IN WELLS GRAY PROVINCIAL PARK

by

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Report prepared for:

Ministry of Environment
Wildlife Branch
Victoria, B.C.

Ministry of Parks
1265 Dalhousie Drive
Kamloops, B.C.

Wildlife Bulletin No. B-68
March 1990

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91-00130/

"Wildlife Bulletins frequently contain preliminary data, so conclusions based on these may be subject to change. Bulletins receive some review and may be cited in publications. Copies may be obtained, depending on supply, from the Wildlife Branch, Ministry of Environment, Parliament Buildings, Victoria, B.C. V8V 1X5."

Canadian Cataloguing in Publication Data
Seip, Dale R.
Ecology of woodland caribou in Wells Gray Provincial Park

(Wildlife bulletin, ISSN 0829-9560 ; no. B-68)

Issued by the Wildlife Branch.
Includes bibliographical references.
ISBN 0-7726-1166-1

1. Caribou - British Columbia - Wells Gray Provincial Park - Ecology. I. British Columbia. Ministry of Environment. II. British Columbia. Wildlife Branch. III. British Columbia. Ministry of Parks. IV. Title. V. Series: Wildlife bulletin (British Columbia. Wildlife Branch) ; no. B-68.

QL737.U55S44 1990 599.73'57 C90-092201-X

SUMMARY

1. The purpose of this project was to gather information for the development of a management plan for caribou in Wells Gray Provincial Park. Necessary information included seasonal movements and habitat use; and population parameters and status of the caribou. Radio-collared caribou were monitored from 1986 to 1989. Additional data on movements and habitat use of wolves and moose were collected to determine predator-prey interactions between caribou, wolves and moose.

2. Most caribou migrated 20-60 km from winter ranges in Highland areas in the southern and western sections of the park to summer ranges in the rugged Cariboo Mountains in the interior and northern sections of the park. However, some caribou remained in the Cariboo Mountains or in Highland areas year-round.

3. In early winter, caribou that spent the winter in the Cariboo Mountains used low elevation cedar/hemlock and mid elevation spruce/subalpine fir forests. Caribou that spent the winter in Highland areas used mid elevation spruce/subalpine fir and upper elevation subalpine fir/spruce forests in early winter. As winter progressed, caribou moved to higher elevations into open subalpine fir/spruce forest types.

   In spring, some caribou used low elevation habitats and fed on new vegetative growth but most remained in subalpine habitats. In summer/fall, most caribou locations were at high elevations in subalpine and alpine.

4. The annual mortality rate for adult, female caribou was 8%. The pregnancy rate for adult females was 93%. Following the calving period in June, 58% of radio-collared, adult females had surviving calves and in October, 37% of radio-collared females had calves. In March, calves constituted 15% of the population. Therefore, recruitment appeared to be sufficient to balance adult mortality and allow slow population growth.

5. The caribou population in the park was estimated at 250 animals, based on March counts corrected for sightability. An additional 50 caribou lived immediately adjacent to the park.

6. Wolf locations and movements were closely related to movements of moose. Caribou were separated from wolves and moose in winter by spatial separation and differential habitat use. Migration of caribou to the Cariboo Mountains in summer reinforced the separation of caribou from wolves and moose. The low predation rate on caribou appeared to be related to this spatial separation and differential habitat use that kept caribou separate from wolves for most of the year.

7. Historic declines in the Wells Gray caribou population are attributed to the colonization of the area by moose in the late 1920's and a resultant increase in wolves and wolf predation on caribou. The migratory behavior of most of the remaining caribou appears to be allowing them to survive despite the presence of moose and wolves. However, subpopulations of caribou within the park which spend the summer in close proximity to moose and wolves appear to be declining.

8. Management recommendations include:

   - protection of old-growth cedar/hemlock and subalpine fir/spruce forest habitats from fire, logging and disturbance.
   - maintaining the wolf population at low numbers by keeping the moose population low and thereby preventing increased wolf predation on caribou.

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INTRODUCTION

Woodland caribou (*Rangifer tarandus caribou*) were abundant in southeastern British Columbia in the early 1900's but populations declined or disappeared from much of their historic range by the mid-1970's (Bergerud 1978; Stevenson and Hatler 1985). Wells Gray Provincial Park is a major population center for the remaining caribou in southeastern British Columbia. Therefore, Wells Gray Park and the adjacent area has been classed as a high priority caribou management area to ensure the continued survival of caribou in southeastern British Columbia (Stevenson and Hatler 1985).

The purpose of this research project was to collect information on the ecology of woodland caribou in Wells Gray Park and the adjacent area that would contribute to improved management and conservation of the caribou. Information on seasonal movements and habitat use was required to improve habitat protection and management policies, including fire management. There was a need to develop an accurate censusing technique and to determine the number of caribou in the park. Information on the reproductive rate, mortality rates and important limiting factors was required to determine if the population was increasing or decreasing and why. Data on movements and habitat use of wolves (*Canis lupus*) and moose (*Alces alces*) were required to clarify the predator-prey interactions between wolves, caribou and moose.

Funding for this project was provided by the British Columbia Ministry of Parks, Science Council of B.C. and World Wildlife Fund, Canada. Rob Woods captured the caribou, Ron Sumanik captured the wolves and Doug Jury and Tom Smith captured the moose. Staff members from B.C. Parks Thompson River District assisted with all aspects of the project. Aircraft pilots included Gideon Schutze, Tom Arduini and Al Peltier. Irene Teske assisted with data analyses and preparation of graphics. Numerous other individuals assisted with the capture programs, calf counts and censuses.

OBJECTIVES

1. To determine seasonal movements and habitat use patterns of caribou in the park.

2. To determine the population size, mortality rates, reproductive rate and important limiting factors of the caribou.

3. To determine seasonal movements and habitat use of wolves and moose and relate this information to predator-prey interactions between wolves, caribou and moose.

STUDY AREA

Wells Gray Park is a 5200-km^2 wilderness area in southeastern British Columbia (Fig. 1). The western side of the park is in the Quesnel Highlands physiographic region and the southern part of the park is in the Shuswap Highland (Holland 1976). These Highlands consist of gentle to moderately sloping plateaus ranging between 1500-2100 m dissected by rivers and lakes at 800-1000 m. The interior, northern and eastern sections of the park are in the Cariboo Mountains. These mountains are steep and rugged with extensive glacier cover. Peaks >2500 m are common.

Annual precipitation in the park is high. Snow accumulations at upper elevations exceed 2 m and are greater in the Cariboo Mountains than in Highland areas (Ministry of Environment 1985).

The Interior Cedar Hemlock (ICH) Biogeoclimatic Zone occurs at low elevations up to 1200-1350 m (Lea 1986).

Forests in the ICH zone are dominated by western redcedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*) with a moss understory and sparse shrub layer. The Engelmann Spruce Subalpine Fir (ESSF) Zone occurs above the ICH up to about 1800 m. The lower elevations of the ESSF are designated the ESSFm subzone and the upper elevations constitute the ESSFu subzone. The ESSFmp subzone is an open parkland habitat that often occurs between the ESSFu and alpine. Within the ESSF, Engelmann spruce (*Picea engelmannii*) becomes less common and open stands of subalpine fir (*Abies lasiocarpa*) become more common with increasing elevation. A dense shrub layer of white rhododendron (*Rhododendron albiflorum*) occurs in much of the ESSF zone. Alpine Tundra (AT) occurs above the ESSF. Much of the alpine zone contains barren rock and glaciers.

Figure 1. Map of study area in Wells Gray Provincial Park. The 2200-m contour interval indicates areas of rugged mountain.

METHODS

Twenty-five caribou were captured in March 1986, by net-gunning from a helicopter in open, subalpine habitats. Four more were captured in March 1987, and one in March 1988. We concentrated our capture effort on adult females so the sample of collared caribou at time of capture consisted of 27 adult females, 1 adult male, 1 female yearling (22 months) and 1 female calf (10 months). Capture effort was distributed throughout the park and immediately adjacent (within 5 km) to the park.

The netted caribou were tranquilized with an injection of 0.75 - 1.0 ml. of Rompun (Xylazine hydrochloride) and restrained with leg hobbles during handling. The animals were fitted with radio collars that had motion-sensitive mortality sensors. Coloured eartags were attached to each animal to aid visual identification of individuals.

A blood sample was collected from the front leg vein of each caribou. Blood was centrifuged and plasma was removed and frozen for storage. Plasma progesterone concentration was determined by radioimmunoassay (B.C. Biomedical Laboratory, Burnaby) to determine if caribou were pregnant at time of capture.

Two wolves were captured in neck snares placed around baits and radio collared in February 1987. They belonged to different packs so their movements represented the movements of the two primary wolf packs living in the park. Nine moose (8 female, 1 male) were captured and radio collared in February 1988 by darting from a helicopter with the immobilizing drug Carfentanyl.

The radio-collared animals were located from an airplane biweekly between April 1986 and March 1989. Co-ordinates of locations were coded on a computer for plotting and home range analyses. Seasonal home ranges were calculated by the minimum convex polygon method using the HOME program (Harestad 1981). Elevation, aspect, habitat type and biogeoclimatic subzone (determined from a biogeoclimatic subzone map) were recorded for each location.

Caribou that died (indicated by mortality signal from radio collar) were necropsied to determine cause of death. Position of the carcass, predator sign and bone marrow fat content were used as clues to determine the cause of death.

Caribou calf counts were conducted from a helicopter in late June, August and October each year. Each radio-collared caribou was observed to determine if it had a surviving calf. In addition, uncollared cows and calves seen with the radio-collared caribou were recorded.

The population was censused (Appendix B) from a helicopter each year in late March when most of the caribou were in open, subalpine habitat. All of the park and areas immediately adjacent to the park were searched by flying along treeline in every watershed. Subalpine meadow complexes on plateaus were also searched. Caribou tracks in the snow were extremely obvious and easy to see. When tracks were found, the area was searched until the caribou were located. Number of adults, calves and collared animals were recorded. Adults were not classified by sex. The census route was directed by the pilot who did not have prior knowledge of where collared caribou were located, thereby preventing a biased search. A sightability correction factor (proportion of collared animals seen during the census) was calculated to correct the total census count for animals that were missed.

RESULTS

SEASONAL MOVEMENTS AND HOME RANGES

In winter, most radiocollared caribou were located in the Shuswap Highland in the south of the park (35 winter home ranges) or in the Quesnel Highlands in the west of the park (12 winter home ranges)(Fig. 2, Appendix A). However, some radio-collared caribou did winter in the Cariboo Mountains (18 winter home ranges). Proportions of caribou counted in the different areas during the March censuses (Shuswap Highland 45%, Quesnel Highlands 15%, Cariboo Mountains 40%) indicated that the radio-collared sample generally represented the entire population, but may have somewhat underestimated the number of caribou that spent the winter in the Cariboo Mountains.

In May, most radio-collared caribou that had wintered in Highland areas migrated to the Cariboo Mountains for the summer. Most summer locations, therefore, were in the Cariboo Mountains (Fig. 3). Many caribou used the same calving location each year although others were located in quite different areas at calving time from one year to the next (Appendix A). In November, many of the caribou migrated from summer ranges in the Cariboo Mountains back to winter ranges in the Highlands. Many of the caribou that remained in the Cariboo Mountains for the winter moved to the periphery of the mountain block north of Kostal Lake or on the east side of Hobson Lake (Fig. 2).

Some general migration patterns were apparent (Table 1, Appendix A) but numerous exceptions and year-to-year variations occurred:

- Some caribou migrated and used similar winter and summer ranges each year.
- Some caribou migrated but did not use the same seasonal ranges each year.
- Some caribou did not migrate.

Average summer home range size was 101 km^2 and ranged from 7 to 345 km^2 (n = 62). Average winter home range size was 95.4 km^2 and ranged from 8 to 384 km^2 (n = 60). Annual home ranges for non-migratory caribou averaged 91.6 km^2 and ranged from 34.5 to 247 km^2 (n = 8). Straight line distances between summer and winter ranges for migrating caribou ranged from about 20 to 60 km. However, those areas do not represent true home ranges (sensu Burt 1943) because the caribou did not regularly use the entire area throughout the season. Rather, the polygon represents the outer boundaries of the area that the caribou moved through during the season. Much of the area within the polygon was never actually used by the caribou.

SEASONAL HABITAT USE

Early Winter: In November - December, there were two distinct patterns of habitat use. Caribou which spent the winter in Highland areas used primarily mid-elevation, spruce/subalpine fir forests in the ESSFm subzone and upper elevation subalpine fir/spruce forests in the ESSFu subzone (Figs. 4, 5). In contrast, caribou which spent the winter in the Cariboo Mountains used primarily low elevation cedar/hemlock forests in the ICH zone and mid-elevation spruce/subalpine fir forests in the ESSFm subzone. Use of lower elevations by some of the caribou in early winter was reflected by a lower average and a wide range in elevations used by caribou at that time of the year (Fig. 6).

Areas used during early winter in the Cariboo Mountains differed from those used in late winter whereas areas used during early winter in the Highlands were similar to those used in late winter (Fig. 2). Cedar/hemlock forests along Azure and Clearwater Lakes were the primary low elevation early winter ranges used by radio-collared caribou.

Late Winter: As winter progressed, caribou moved to higher elevations (Figs. 6, 7). In January-February, about 60% of the caribou locations were in the upper elevation ESSFu subzone, 30% in the mid-elevation ESSFm subzone and 10% in the ESSFmp subzone (Fig. 8). Low elevation cedar/hemock forests in the ICH were rarely used.

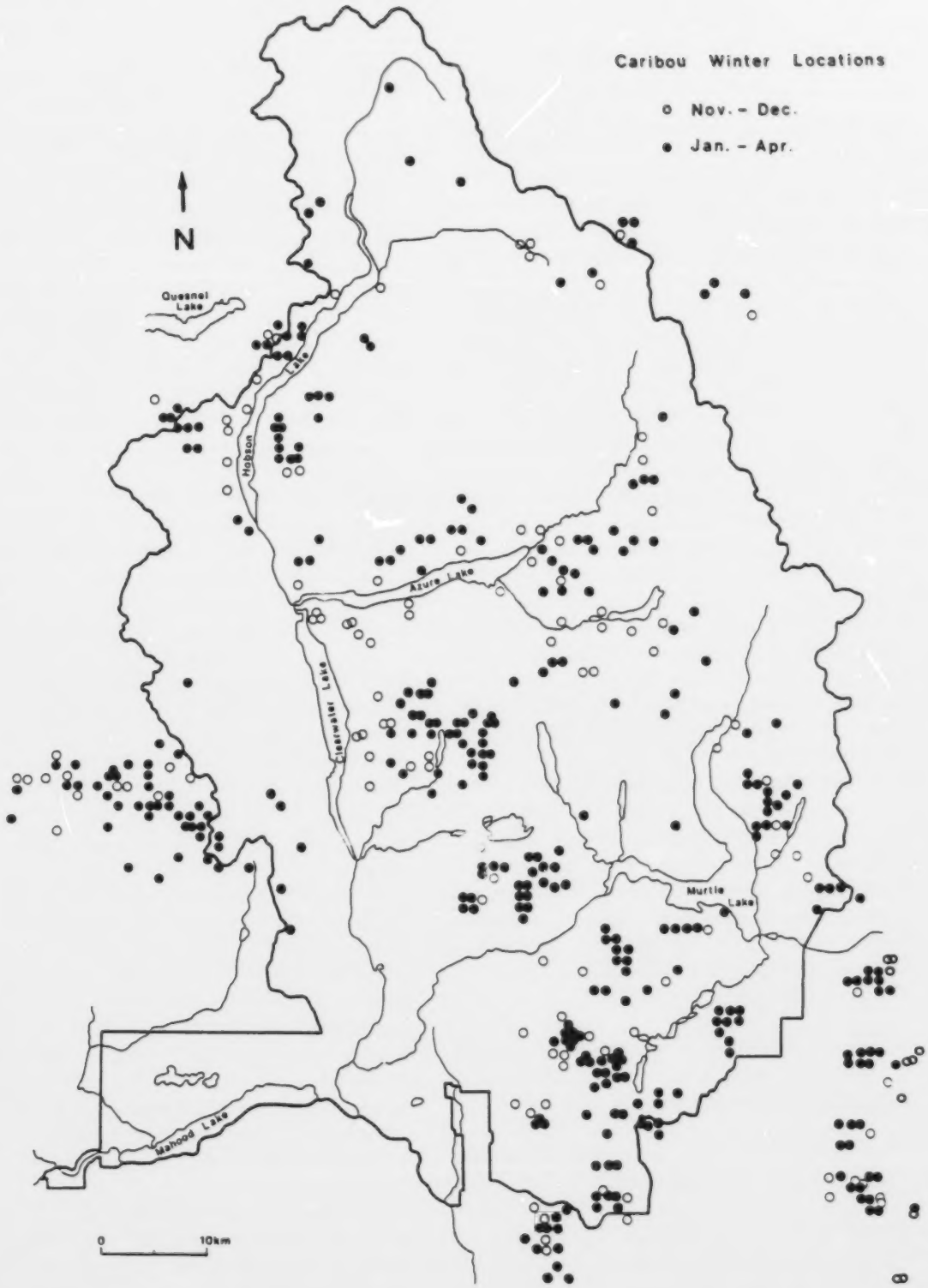

Figure 2. Winter locations (Nov-Apr) of radio-collared caribou, 1986-89. Each point may represent >1location.

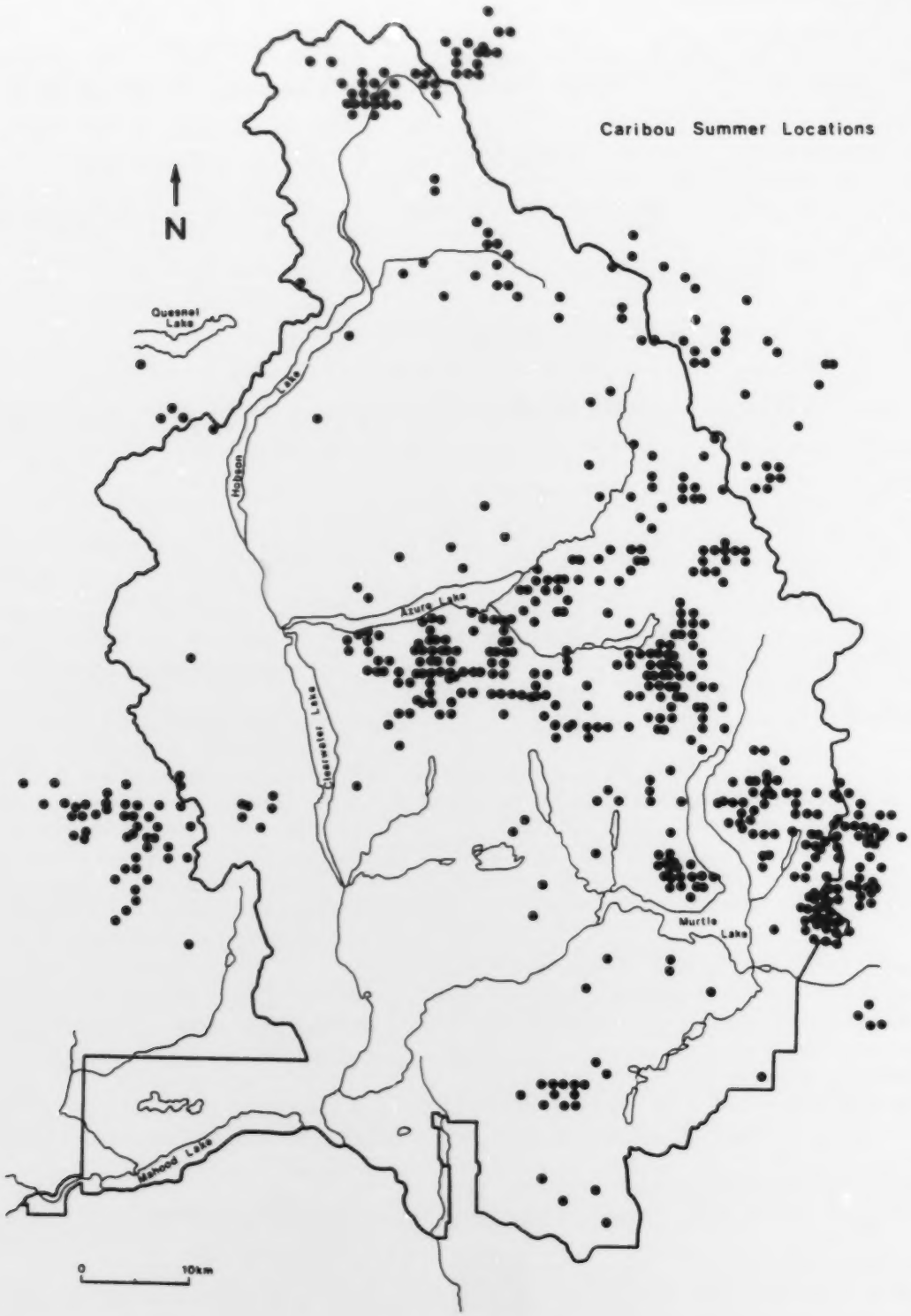

Figure 3. Summer locations (May - Oct) of radio-collared caribou, 1986-88. Each point may represent >1 location.

Table 1. General migration patterns of radio-collared caribou in Wells Gray Park (see Appendix A).

No. of Caribou	Winter Range	Summer Range
5	Battle-Trophy Mts., Kilpill-Pillpill Mts., and plateau southwest of Murtle L.	Area between Murtle Lake, Azure Lake and Angus Horne Lake
4	Upper Raft R.	East of Murtle Lake
4	Hobson Lake area	Headwaters of Clearwater R.
3	Kostal/Ray Lake area	South of Azure Lake
4	Interior of park around Mt. Hogue	Same, no migration
4	Boss-Deception Mt.	Most did not migrate but "H" moved to Angus Horne Lake area

About 30% of the locations in January-February were in sparsely forested habitats including subalpine parkland and meadows, clearcuts and burns and about 60% of locations were in forested habitats (Fig. 9).

In March-April, caribou were found primarily in high elevation, open habitat types. About 50% of locations were in the ESSFu subzone; 30%, in the ESSFmp subzone. About 60% were in sparsely forested habitats; 40%, in forested habitats.

Throughout the late winter period, areas of gentle topography such as plateaus, bowls and ridge tops were used more regularly than steeper slopes. There was no indication that caribou preferentially selected any aspect (Fig. 10).

Spring: In May, some caribou used low elevation habitats in the ICH zone including cedar/hemlock forests, slides and burns (Figs. 7,8,9). However most caribou used mid and high elevation subalpine fir/spruce forests and subalpine parkland habitats in the ESSF zone. Use of low elevations by some caribou was reflected by a decrease in the average elevation of caribou locations in May (Fig. 6).

Summer/Fall: Throughout the summer/fall period (June - October), caribou were located

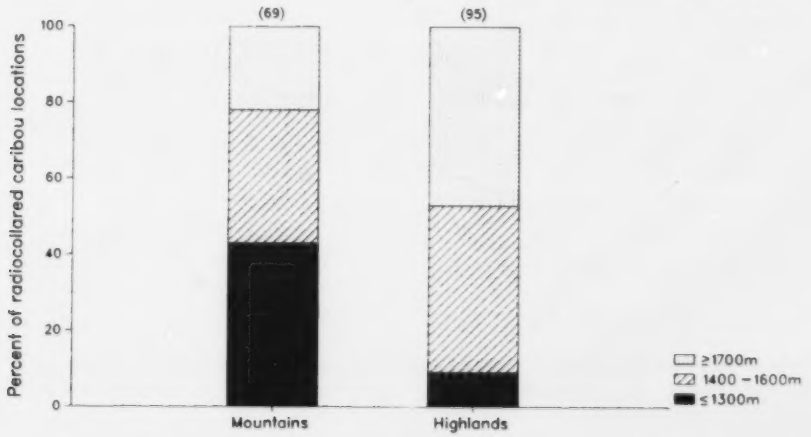

Figure 4. Proportion of radio-collared caribou locations at different elevations during early winter (Nov-Dec). Sample size is given above each bar.

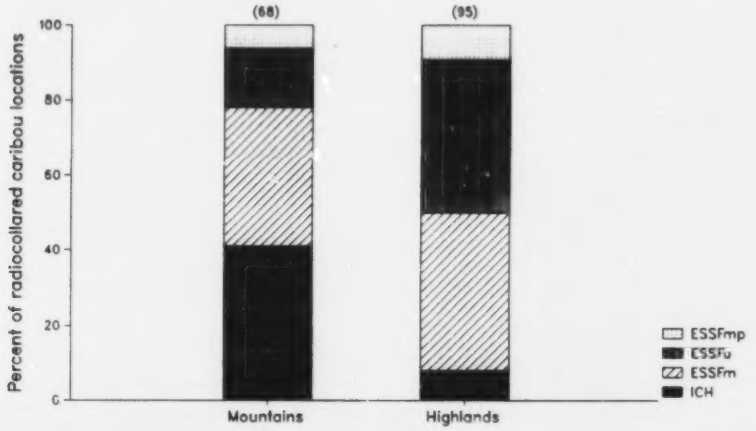

Figure 5. Proportion of radio-collared caribou locations in different biogeoclimatic subzones during early winter (Nov-Dec). Sample size is given above each bar.

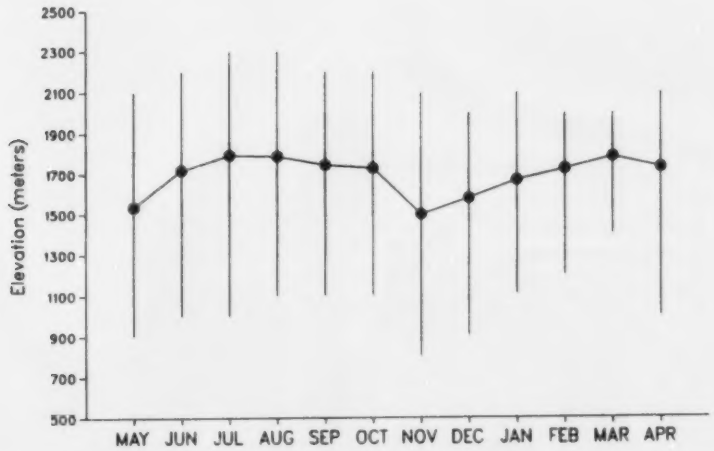

Figure 6. Monthly average and range of elevations used by radio-collared caribou, 1986-89.

primarily at high elevations in the ESSFu, ESSFmp and AT subzones (Fig. 7,8). Most locations were in open habitats including alpine, subalpine parkland, subalpine meadows and burns (Fig. 9). However there was also substantial use of subalpine fir/spruce forests. There was no apparent selection for specific aspects during the summer/fall period (Fig. 10)

POPULATION PARAMETERS AND LIMITING FACTORS

Adult Mortality: Six radio-collared caribou died during 76 caribou-years of monitoring for an annual adult mortality rate of 8%. Bear predation was the major cause of mortality (Table 2). Only one collared caribou was killed by wolves. Most of the adult mortality (5/6, 83%) occurred during summer (June - August) and one died in early winter. No adult caribou died during the late winter period. The average elevation of mortalities caused by bear and wolf predation (1375 m $\pm$ 110.9 [SE]) was lower than the average elevation of caribou locations throughout the summer (Fig. 6), which suggests that caribou at low elevations were more vulnerable to predators.

Pregnancy Rate: Plasma progesterone concentrations indicated that 25/27 (93%) adult, female caribou were pregnant when captured in March (Table 3). The female yearling and female calf were not pregnant.

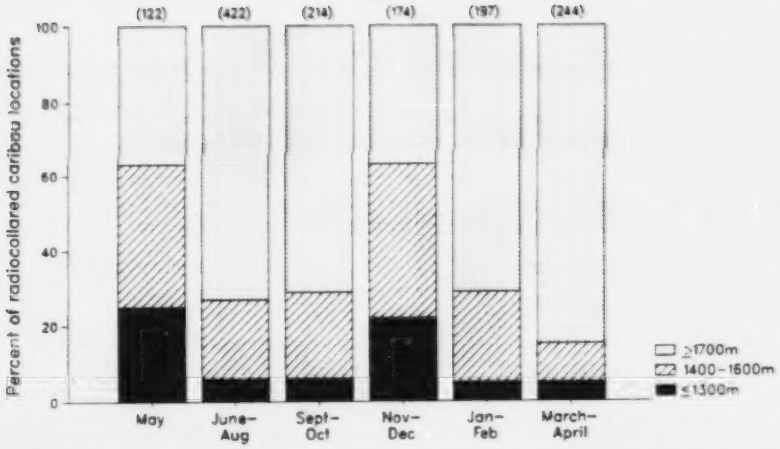

Figure 7. Proportion of radio-collared caribou locations at different elevations during different seasons, 1986-89. Sample size is given above each bar.

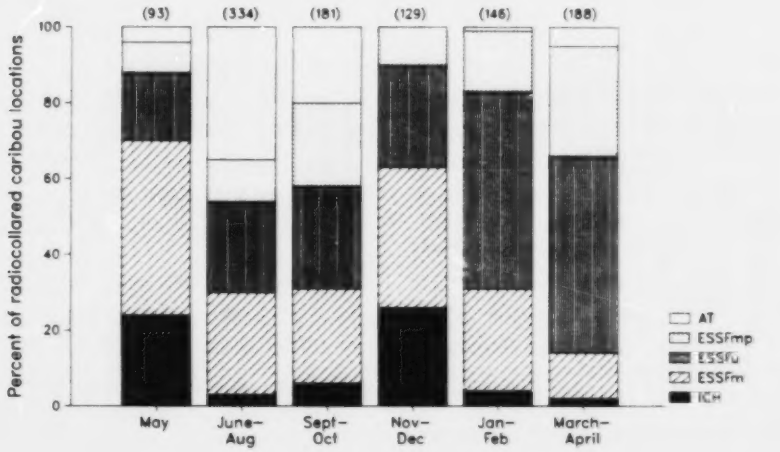

Figure 8. Proportion of radio-collared caribou locations in different biogeoclimatic subzones during different seasons, 1986-89. Sample size is given above each bar.

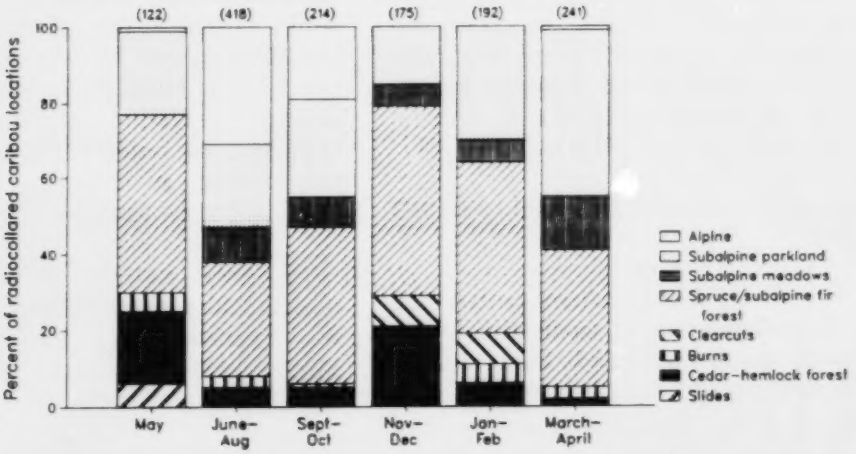

Figure 9. Proportion of radio-collared caribou locations in different habitat types during different seasons, 1986-89. Sample size is given above each bar.

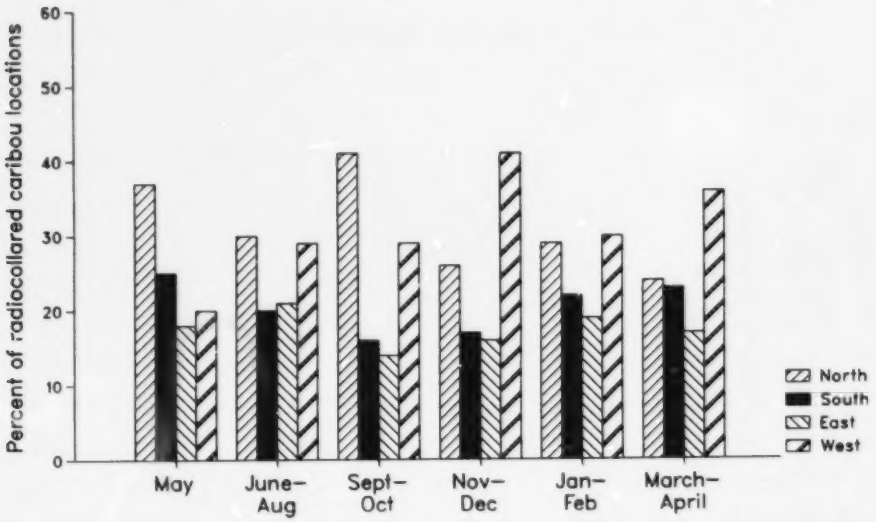

Figure 10. Proportion of radio-collared caribou locations on different aspects during different seasons, 1986-89.

Calf Production and Survival: In late June, immediately following the calving period, an average of 58% of the collared adult females had surviving calves (Fig. 11). At the same time, about 44% of all cows seen had calves (Fig. 12). The calf count for all cows seen was lower than the count for collared adult females because some of the uncollared cows would have been immature females or possibly misidentified young bulls. Not much variation occurred in the June calf counts between years. Although caribou usually have only one calf, one case of apparent twinning was observed in June 1988, when two cows were accompanied by 3 calves.

Proportion of cows with calves decreased gradually throughout the summer. By October about 37% of collared cows and 30% of all cows seen had surviving calves. In March, surviving calves constituted on average 15% of the population (17.7 calves/100 adults)(Table 4).

Calf survival for caribou that spent the summer in the mountains east of Murtle Lake and in the Boss-Deception Mountain area was lower than calf survival for caribou that spent the summer in the central and northern sections of the park. During October calf counts, 7% (1/14) of the radio-collared caribou that spent the summer in those two areas had surviving calves compared to 44% (22/50) of the collared cows that lived in the interior and northern sections of the park in

Table 2. Causes of mortality of radio-collared, adult, female caribou in Wells Gray Provincial Park, 1986-88.

Cause	Number	Date	Elevation (m)
Bear predation	3	July 1986 June 1987 July 1987	1200 1300 1700
Wolf predation	1	August 1987	1300
Unknown	2	December 1986 August 1988	1000 -

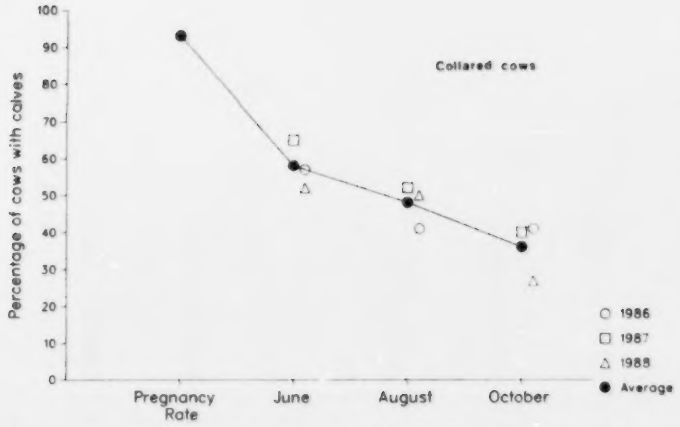

Figure 11. Proportion of radio-collared, adult, female caribou with surviving calves throughout the summer, 1986-88.

summer. In March counts, calves constituted 7% (7/97) of the population in the Upper Raft River area (caribou that were east of Murtle Lake in summer) and the Boss-Deception Mountain area compared to 16% (93/569) of the population in other areas of the park.

Population Size: The proportion of collared animals seen during the March censuses ranged from 66% to 87%. The low value occurred in 1988 when the census was hampered by poor weather conditions. Snowstorms, clouds and fog greatly reduced visibility and prevented access to some areas. Weather conditions in 1987 and 1989 were clear and sunny and under those conditions, an average of 83% of the collared animals were seen.

The primary reason that collared animals were missed was a failure to see collared individuals even though the group it was in was found and counted. Individual caribou often broke off from the main group when the helicopter was overhead and some of these animals were missed in the count. Almost all groups that contained radio-collared caribou were detected during censuses when weather conditions were clear.

The population estimate for the park remained almost identical over 3 years at about 250 caribou (Table 5). The population estimate for the park and adjoining areas was higher in 1989 than in preceding years but this increase was largely due to more extensive searching in the Deception Mountain area that year. Overall, the population censuses indicated a stable population in the park and adjacent area during the study period.

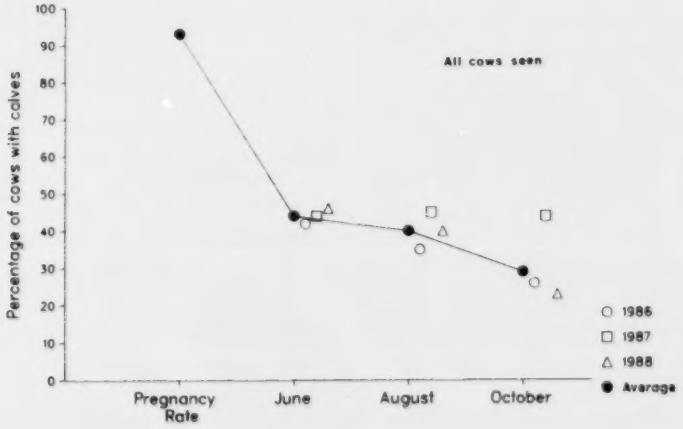

Figure 12. Proportion of all cows seen (collared and uncollared) with surviving calves throughout the summer, 1986-89.

Table 3. Plasma progesterone concentrations (ng/ml) of female caribou in March.

Age/status	*N*	$\bar{x}$	S.D.	Range
Pregnant, adult females	25	4.6	1.02	3.1 - 6.5
Non-pregnant, adult females	2	0.15	-	0.1 - 0.2
Female yearling	1	0.1	-	-
Female calf	1	0.1	1	1

Table 4. Proportion of calves in the Wells Gray caribou population during March censuses, 1987-89.

Year	No. of Adults	No. of Calves	% Calves	Calves/100 adults
1987	182	39	17.7	21.4
1988	157	24	13.3	15.3
1989	226	37	14.1	16.4
Average			15.0	17.7

SEASONAL MOVEMENTS AND HABITAT USE OF WOLVES AND MOOSE

In winter, the radio-collared moose were concentrated in the southern section of the park on Green Mountain and along Hemp Creek (Fig. 13). Two of the collared moose spent the winter along the upper Clearwater River above Hobson Lake. Numerous uncollared moose were regularly seen in those two areas. Moose were not commonly seen in other areas of the park during winter telemetry flights, helicopter surveys or capture programs. Therefore, data for the radio-collared moose are believed to be representive of the park moose population.

Wolf locations in winter were primarily in the southern part of the park in areas used by moose (Fig. 13). Moose and wolves remained primarily at low elevations in the ICH zone during the winter months (Fig. 14,15,16). Moose used a combination of spruce, aspen and pine forests, burns and shrublands during winter (Fig. 17). Throughout the winter months, wolves were closely associated with moose but both wolves and moose were separated from caribou by spatial separation and differential use of elevations and habitat types (Fig. 13,14,15,16).

In summer, moose that wintered in the Hemp Creek area migrated 10 - 30 km north and used

Table 5. Population census results for caribou in Wells Gray Provincial Park, 1987-89.

Year	% collared caribou seen	No. of caribou counted in Park	Park population estimate	No. counted in and adjacent to Park	Total population estimate
1987	78 (18/23)	192	246	221	275
1988	66 (14/21)	162	245	181	274
1989	87 (20/23)	220	253	263	302

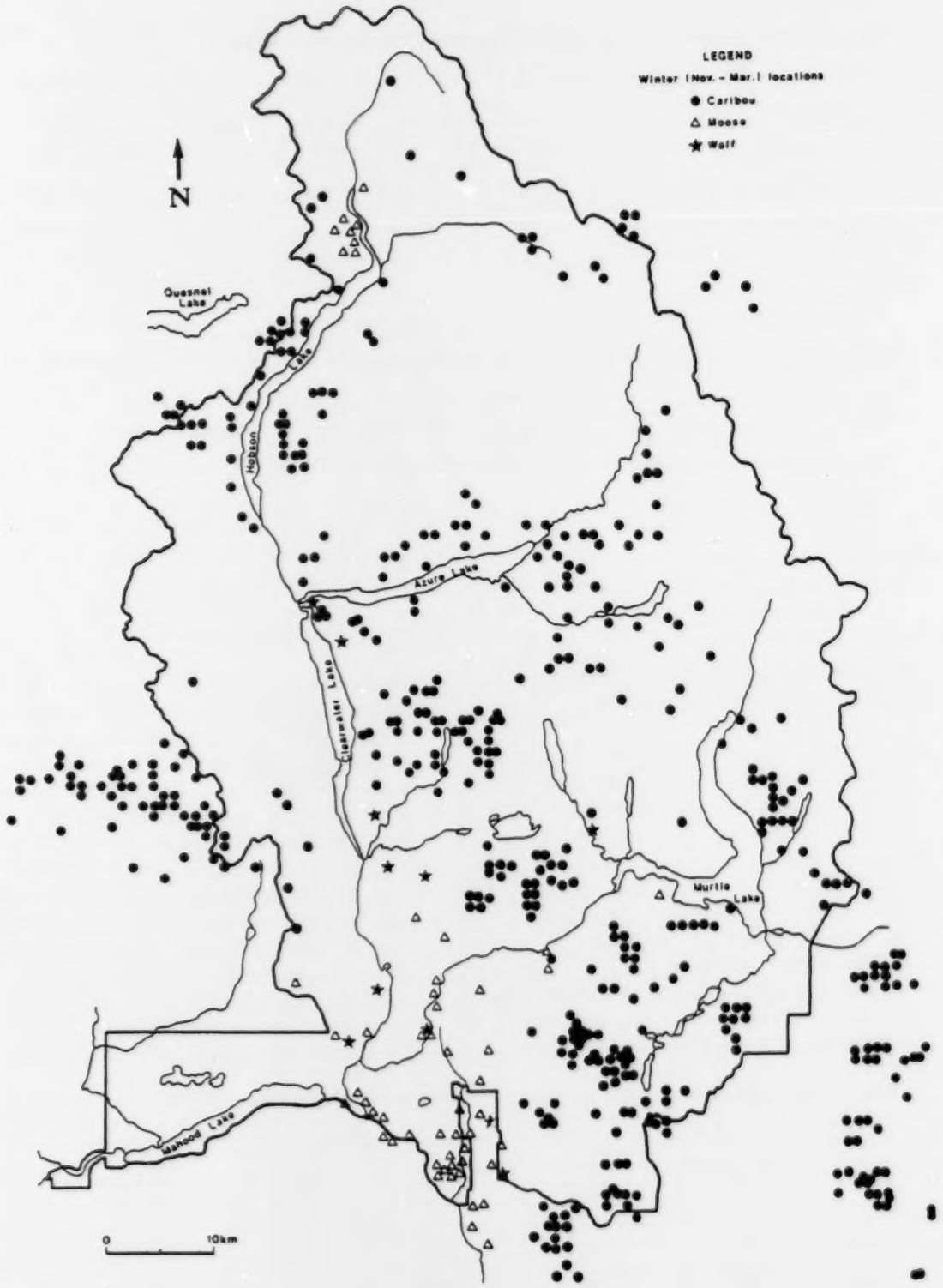

Figure 13.Locations of radio-collared caribou, wolves, and moose during winter (Nov-Apr).

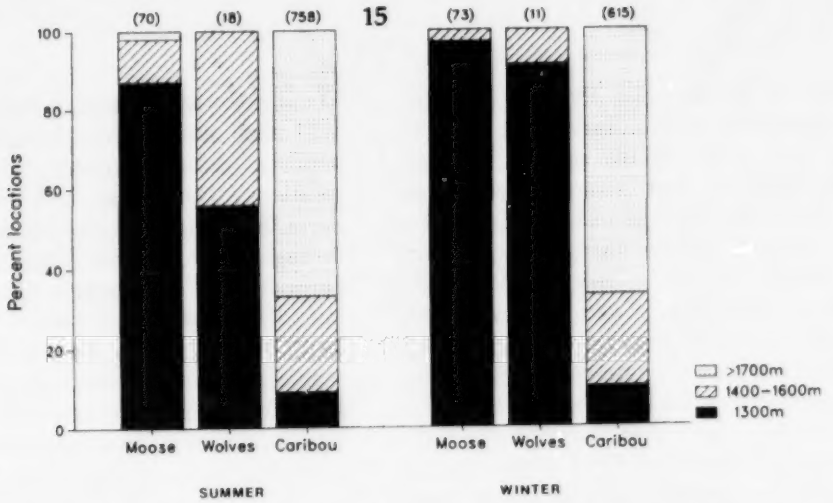

Figure 14. Proportion of radio-collared moose, wolf and caribou locations at different elevations in summer and winter. Sample size is given above each bar.

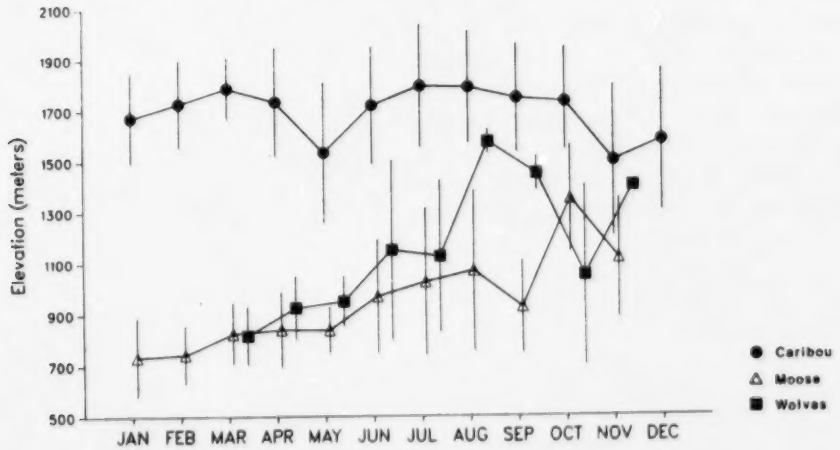

Figure 15. Average elevation (± SD) of radio-collared moose, wolves and caribou throughout the year.

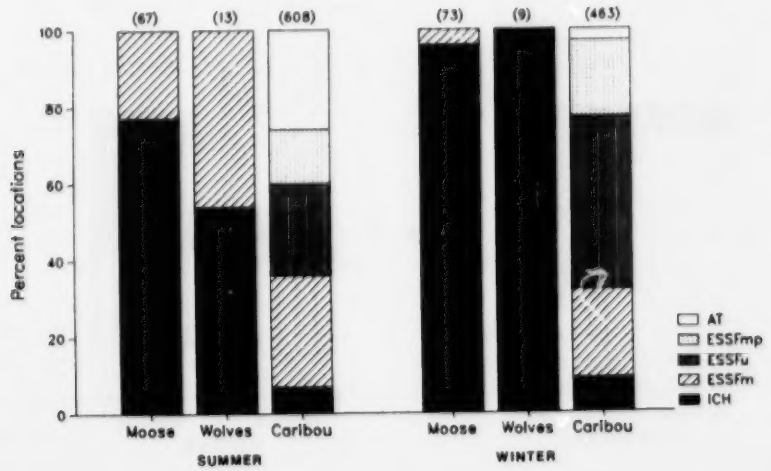

Figure 16. Proportion of radio-collared moose, wolf and caribou locations in different biogeoclimatic subzones in summer and winter. Sample size is given above each bar.

areas south of Murtle Lake, Pyramid Mountain and the southern end of Clearwater Lake (Fig. 18). The two moose in the upper Clearwater River remained in that general area during summer. One of the wolf packs used the southern section of the park and the other pack moved into the periphery of the Cariboo Mountains northwest of McDougall Lake and overlapped areas used by caribou (Fig. 18). Incidental observations and data from radio-collared wolves at Quesnel Lake indicated that wolves also occurred in the Upper Raft River/Murtle Lake area, the upper Clearwater River above Hobson Lake and in the Crooked Lake area near Boss-Deception Mountain.

Moose used higher elevations in summer than in winter but most locations were still at low elevations in the ICH (Figs. 14, 15, 16), although there was also some use of the mid elevation ESSFm subzone. Moose at low elevations used primarily spruce/wetland complexes and forests. Moose at higher elevations in summer used spruce/subalpine fir forests and subalpine meadows.

The wolves were found at low elevations in the ICH zone and at mid-elevations in the ESSFm subzone during summer, similar to moose locations. There was little overlap in space, elevation or habitat between moose and caribou throughout the summer. There was some overlap between wolf and caribou locations in summer but little overlap in elevation and habitat (Fig. 14,15,16,18). Therefore, caribou were largely separated from wolves and moose by spatial separation and differential use of habitats and elevations in summer as well as winter.

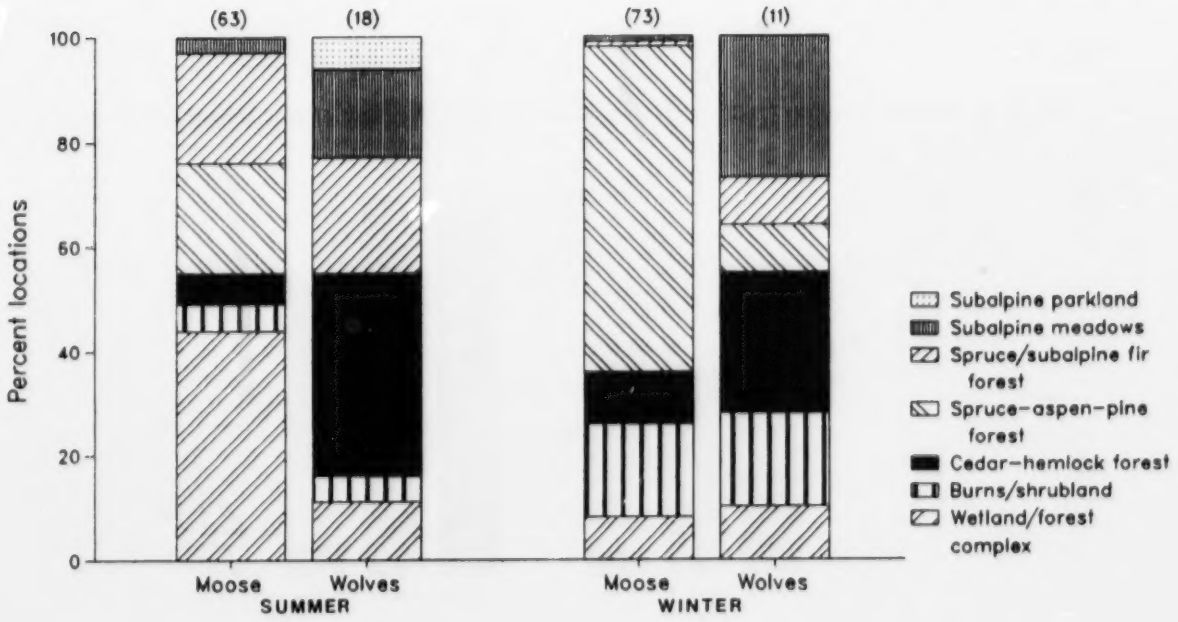

Figure 17. Proportions of radio-collared moose and wolf locations in different habitat types in summer and winter. Sample size is given above each bar.

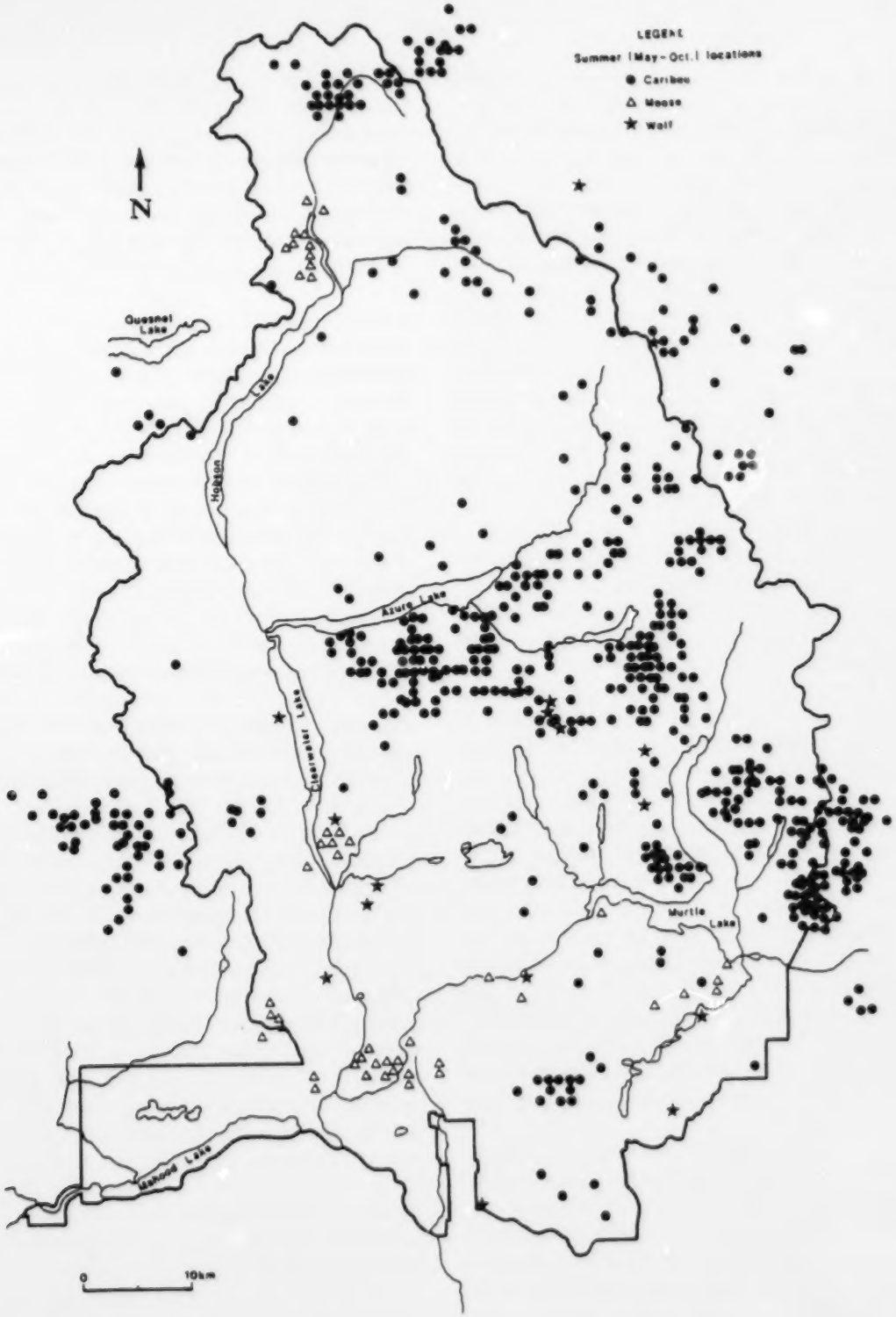

Figure 18. Locations of radio-collared caribou, wolves and moose during summer (May-Oct).

DISCUSSION

SEASONAL MOVEMENTS AND HABITAT USE

Early Winter: In early winter, when deep, soft snow began to accumulate at high elevations, a large proportion of the caribou that had spent the summer in rugged mountains in the central and northern parts of the park migrated 20 to 60 km to Highland areas in the south and west of the park. Caribou that remained in the Cariboo Mountains for the winter usually migrated to the periphery of the rugged mountain block or to areas of gentle topography within the Cariboo Mountains. Therefore, few caribou were located on steep slopes during the winter period.

Caribou that moved to Highland areas for the winter used mid-elevation, spruce/subalpine fir forests in the ESSFm subzone and upper elevation, subalpine fir/spruce forests in the ESSFu subzone. In contrast, caribou that spent the early winter in the Cariboo Mountains used primarily low elevation cedar/hemlock forests in the ICH zone and mid-elevation spruce/subalpine fir forests in the ESSFm subzone.

Use of lower elevation habitats in the Cariboo Mountains was probably due to caribou avoiding deep, soft snow at higher elevations that would make movement extremely difficult and energetically costly on steep slopes. In contrast, the gentler terrain and lower snowfall in the Highland areas allowed those caribou to use mid and high elevation forests in early winter. Few caribou used open, sparsely forested habitats during early winter, presumably due to higher accumulations of deep, soft snow in open areas compared to forests.

Extensive use of low elevation forests in the ICH and lower ESSF zones during early winter was also reported for caribou in rugged, mountainous study areas at Revelstoke and the Selkirks (Simpson *et al.* 1987; Rominger and Oldemeyer 1989; Servheen and Lyon 1989). However, in the Quesnel Highlands around Quesnel Lake, caribou used primarily mid and upper elevations in the ESSF zone in November - December (Seip 1988). Therefore, the tendency for caribou in rugged mountains to use low elevation cedar/hemlock and mid elevation spruce/subalpine fir forests while caribou in Highland areas use mid and upper elevation subalpine fir/spruce forests in early winter appears to be general throughout southeastern British Columbia.

Caribou that use cedar/hemlock forests in early winter feed on shrubs, especially Falsebox (*Paxistima myrsinites*), and arboreal lichens including *Alectoria* spp. and *Bryoria* spp. (Simpson *et al.* 1987; Scott and Servheen 1985; Antifeau 1987). Windthrown trees provide a major proportion of the arboreal lichens that are eaten. Forbs are eaten if snow depths are shallow enough to allow cratering. Food availability appears to be quite limited in cedar/hemlock forests during early winter (Simpson *et al.* 1987; Antifeau 1987). Caribou that use spruce/subalpine fir forests in early winter feed primarily on arboreal lichens (Antifeau 1987).

Arboreal lichens are most abundant in old-growth forests because lichens require a slow-growing or decadent substrate on which to grow. Old-growth stands also provide good snow interception and abundant shrub production compared to younger second-growth stands. Therefore, it is important to protect adequate amounts of old-growth forest to provide early winter habitat for caribou (Simpson *et al.* 1987; Rominger and Oldemeyer 1989). Substantial areas of old-growth, cedar-hemlock and spruce/subalpine fir forests, especially in areas known to be heavily used by caribou, should be protected from fire, logging and other agents of destruction because young, second-growth forests will probably not provide suitable early winter habitat for caribou.

Protection of cedar-hemlock stands appears to be more important in rugged, mountainous areas than in Highland areas.

Late Winter. As winter progressed, caribou gradually moved to higher elevations and made use of more open habitat types such as subalpine parklands and meadows. By March - April, almost all of the caribou were located at high elevations above or near treeline. Caribou

generally avoided steep slopes and selected flatter topography such as bowls, plateaus and ridgetops. There was no apparent selection for aspect. A similar gradual movement to upper elevation forests during winter has been reported for all other studies of caribou in southeastern British Columbia (Antifeau 1987; Simpson *et al.* 1987; Seip 1988; Servheen and Lyon 1989).

Caribou feed almost exclusively on arboreal lichens during mid and late winter (Simpson *et al.* 1987; Seip 1988). Lichens are obtainined primarily by feeding directly on the tree. Conifer needles are injested incidentally while feeding on arboreal lichens.

High elevation, sparsely forested stands have the greatest amount of lichen/tree (Antifeau 1987), probably because the combination of abundant light and very slow tree growth provides excellent growing conditions for lichen. Therefore, high elevation open stands are preferred habitat if snow conditions are firm enough to allow easy movement from tree to tree. Soft snow conditions earlier in the winter cause caribou to use more closed-canopied forests at lower elevations.

Lichen availability in high elevation forests is very abundant and does not currently appear to be an important limiting factor for most caribou populations in southeastern British Columbia (Bergerud 1983; Simpson *et al.* 1987; Seip and Stevenson 1987). However, it remains important to ensure that adequate amounts of old-growth, high elevation forest are protected to provide winter habitat for caribou. Also, these relatively flat, parkland habitats are very attractive to snowmobilers and backcountry skiers so there is a need to ensure that excessive disturbance of caribou is prevented (Simpson 1987).

Spring: In May, most caribou that had spent the winter in Highland areas began to migrate to summer ranges in the Cariboo Mountains. During May, some caribou used low elevation habitats such as cedar/hemlock forests and avalanche chutes but most locations were in mid and upper elevation forests in the ESSF zone, often above snowline. Caribou at low elevations feed on new vegetative growth including grasses, forbs and shrubs (Seip 1988). Caribou that remain at higher elevations continue to feed primarily on arboreal lichens (Seip 1988; Scott and Servheen 1985). Caribou that use low elevations and feed on new vegetative growth have higher fecal nitrogen levels than caribou that remain in the subalpine, indicating that caribou that use low elevations obtain a higher quality diet (Seip 1988). The fact that most caribou use high elevation habitats in spring rather than low elevations where food quality is superior is probably a predator avoidance stategy. The observation that caribou killed by predators were located primarily at low elevations indicated that use of low elevation habitats by caribou made them more vulnerable to predation by bears and wolves.

Summer/Fall: By calving time in June, most caribou were located in the Cariboo Mountains in the interior, northern and eastern sections of the park. Many caribou used the same calving location each year although others were located in quite different areas at calving time from one year to the next.

Caribou were found primarily at high elevations in alpine, subalpine parkland and subalpine meadow habitats throughout summer and early fall. Caribou feed on a variety of grasses, forbs, shrubs and lichen throughout the summer months (Seip 1988).

In late October or early November when snow began to accumulate at high elevations, caribou that had spent the summer in the Cariboo Mountains either migrated to winter ranges in the Highlands or moved to low elevation early winter ranges within or along the periphery of the Cariboo Mountains.

POPULATION PARAMETERS AND POPULATION STATUS

Adult Mortality Rate: The annual adult mortality rate of 8% during the study period was low compared to other study areas in southeastern British Columbia. Seip (1989) reported an annual, adult, mortality rate of 28% for caribou in the nearby Quesnel Lake area during a 5-year study. Wolf predation caused over half of the adult mortality at Quesnel Lake. Simpson and Woods (1987) reported an annual adult mortality

rate of 19%, primarily from accidents. Edmonds and Bloomfield (1984) reported a 21% annual adult mortality rate in west-central Alberta with wolf predation and poaching implicated as major mortality factors. In comparison, adult caribou survival in Wells Gray Park was much higher due to the low wolf predation rate and lack of poaching. However, in recent years, several cases of caribou poaching have occurred adjacent to the park, especially in the Upper Raft River area (Seip and Stevenson 1987).

Calf Production and Survival: The adult, female caribou had a high pregnancy rate of 94%. Although caribou almost always have only one calf, there was one observation of possible twinning in Wells Gray Park (2 cows with 3 calves). The high pregnancy rate is indicative of good nutrition and physical condition of the caribou. Intense competition for food and poor physical condition results in reduced pregnancy rates for caribou and reindeer (Thomas 1982; Skogland 1985; Messier *et al.* 1988).

Although almost all adult female caribou were pregnant, a substantial proportion of calves apparently died during the calving period. Only about 58% of adult females had surviving calves immediately following the calving period. A similar pattern of high calf mortality during the calving period was also reported for Quesnel Lake caribou (Seip 1989). The cause of mortality during the calving period is not known for Wells Gray Park or Quesnel Lake but other studies have found that newborne calves die from a wide variety of causes including birthing problems, birth defects, accidents and predators, especially grizzly bears (*Ursus arctos*) (Page 1985; Adams *et al.* 1988).

Subsequent to the calving period, there was a progressive loss of calves throughout the summer but calf survival remained relatively high with 37% of radio-collared, adult females having surviving calves in October. In March, calves constituted about 15% of the total population (17.7 calves/100 adults).

Assuming that the sex ratio of calves was 50:50, the recruitment rate was about 0.15 female calves/adult female. Yearling survival rate was not determined but was probably similar to the adult rate. Therefore, the recruitment rate appeared to be more than adequate to balance the adult mortality rate and the population should have been slowly increasing.

Although calf survival for the park overall appeared to be adequate to maintain the caribou population, calf survival for some subgroups of caribou was much lower. Calf survival to October for caribou that spent the summer east of Murtle Lake and in the Boss - Deception Mountain area was lower than survival of calves in the central and northern sections of the park (7% vs 44%). Therefore, the segment of the caribou population that spent the summer in those southern portions of the park may be declining due to inadequate calf survival. Census results confirm a major decline in the number of caribou seen in those areas during summer between 1970 and 1984 (Ritcey and Jury 1984).

In the adjacent Quesnel Lake area, wolf predation appeared to be the major mortality factor for caribou calves and calf survival was close to zero when wolves were present in natural numbers (Seip 1989). Numerous other studies have shown the major importance of wolf predation on caribou calf survival (Gasaway *et al.* 1983; Bergerud and Elliot 1986; Adams *et al.* 1988; Farnell and McDonald 1988). The high overall calf survival in Wells Gray Park indicates that wolf predation was not a major mortality factor for calves in most of the park. However, the lower calf survival in the southern sections of the park may have been due to greater wolf predation in those areas than in the central and northern sections of the park.

Population Size and Trend: The current population of about 250 caribou inside the park and 300 caribou in and immediately adjacent to the park in winter is well below historic population levels. As recently as 1970, 308 caribou were counted in the park during a summer count on snowpatches and alpine areas (Ritcey and Jury 1984). It is likely that summer counts used in the past greatly underestimated the actual caribou population. In summer, about 40% of caribou are located in forested habitat where they cannot be seen. Even caribou using alpine and parkland habitats are extremely difficult to see. During calf counts, it often took

several minutes of low level searching from the helicopter to see radio-collared caribou in alpine and parkland habitats even though the radio signal indicated that the animal was in the immediate area. During the summer, <5% of radio-collared caribou locations were on snowpatches where they are highly visible. A summer snowpatch census for caribou in 1984 recorded 55 caribou (Ritcey and Jury 1984) compared to our winter count of 275 in 1987. Therefore, summer snowpatch counts used in the past may have been recording only 5-20% of the caribou. If so, the Wells Gray caribou population in the 1960's and early 1970's when 61-308 caribou were seen during summer counts could have actually been >1000 caribou.

Only subjective estimates of caribou populations before the 1960's are available but apparently they were "extremely abundant" before the 1930's when a major decline occurred (Edwards 1954). Therefore, several thousand caribou may have occurred in the Wells Gray Park area before the decline. If the decline was due to factors other than habitat deterioration, the park should be able to sustain that number of caribou again if the cause of the decline is eliminated or reduced.

POPULATION LIMITATION OF CARIBOU IN WELLS GRAY PARK

The reasons for the major decline in caribou numbers in the 1930's throughout southeastern British Columbia have been a subject of controversy among caribou biologists. Edwards (1954) attributed the decline to the destruction of large areas of lichen-bearing, old-growth forest by fires in the 1930's. Bergerud (1974) and Bergerud and Elliot (1986) proposed that caribou declined due to a combination of overharvesting and increased wolf predation. Increased wolf predation was attributed to the colonization of this area by moose in the late 1920's. They propose that moose sustained increased wolf populations that led to an increased predation rate on caribou.

Recent research results have provided support for the predation hypothesis. In the nearby Quesnel Lake area, wolf predation on caribou calves and adults was the primary cause of a major reduction in the population (Seip 1989). In winter, caribou at Quesnel Lake were spatially separated from wolves and moose, similar to Wells Gray Park, and wolves fed primarily on moose. However in summer, moose and wolves used the same subalpine habitats used by the non-migratory caribou population. During the summer period when caribou, wolves and moose occupied similar areas and habitats, a large proportion of caribou calves and adults were killed by wolves.

Before the colonization of southeastern British Columbia by moose around 1925-30 (Edwards 1956), wolf populations in areas of caribou habitat were probably very low due to a lack of available prey in winter. Use of high elevations by caribou and mountain goats (*Oreamnos americana*) in winter makes them largely invulnerable to wolves. Mule deer (*Odocoileus hemionus*) migrate out of these high snowfall areas for the winter. The colonization by moose provided an alternate prey base that was available at low elevations to sustain the wolf population during the winter months. Increased wolf numbers could then have an increased impact on the caribou population.

The major historic decline in caribou numbers corresponded to the arrival of moose in the Wells Gray Park area. The population may have declined from historic levels of several thousand caribou to the current population of 300 caribou. However, the current population data indicate that the Wells Gray population is stable or slowly increasing whereas the Quesnel Lake population continues to decline due to wolf predation.

The current low level of wolf predation on caribou in Wells Gray Park appears to be related to the spatial and habitat separation between wolves and caribou for most of the year. Locations and habitat use of wolves throughout the year closely corresponded to locations and habitat use of moose. In winter, wolves and moose were located in low elevation shrublands and forests whereas caribou were at high elevations in subalpine forests. In summer, prior to calving, most caribou migrated to rugged, mountainous areas in the northern and interior portions of the park and used high elevation habitat types. Although most moose also migrated to summer ranges, they did not move

into rugged mountains but rather used low to mid-elevation forest/wetland complexes in flat to gently rolling terrain. Wolves were located primarily in areas and habitats used by moose with only minimal spatial and habitat overlap with caribou. Therefore, throughout the year, most caribou were separated from wolves by spatial separation and differential habitat use. That separation, resulting from the caribou migration to rugged, mountainous habitat in summer, is apparently the reason for the low wolf predation rate on caribou.

The migratory behavior of Wells Gray caribou allows them to coexist with wolves and moose by creating spatial separation whereas the non-migratory caribou at Quesnel Lake appear unable to coexist with wolves and moose because they occupy similar summer habitats. Similarly, migration of arctic caribou herds results in a reduced level of wolf predation because breeding wolves are restricted to the vicinity of the denning site and cannot follow the migrating herd. Bergerud *et al.* (1983) and Bergerud and Page (1987) discuss how dispersion of caribou into areas with low predator numbers acts as a predator avoidance strategy.

In the past, it appears that many more caribou in the Wells Gray area spent the summer in Highland areas. Ritcey and Jury (1984) reported that summer census results between 1970 and 1984 indicated a major reduction (141 to 3 caribou seen) in caribou numbers during summer in peripheral, highland areas of the park whereas population declines in the central areas of the park were much less severe (116 to 41 caribou seen). Perhaps many of the caribou that disappeared during the population decline were non-migratory animals that spent the summer in Highland areas where they were vulnerable to wolves. Caribou which exhibited migratory behavior may have been less vulnerable to predation and have survived. During this study, the non-migratory caribou in the Boss - Deception Mountain area and the caribou which spent the summer east of Murtle Lake had low calf survival compared to caribou which migrated to the interior and northern part of the park. This lower calf survival may be related to the closer proximity of moose and wolves in those areas. The Boss - Deception Mountain area has extensive areas of good moose habitat and wolves are reported to be abundant in the area (S. Maitland pers. comm.). The area east of Murtle Lake is adjacent to extensive moose habitat and one radio-collared caribou was killed by wolves in that area. These two subgroups of caribou may continue to decline due to inadequate spatial separation between their calving sites and areas of summer wolf use. However, caribou which migrate to the rugged interior of the park for calving appear to be able to avoid wolves and presently appear to be increasing in numbers.

A declining number and distribution of moose may also have contributed to the apparent present reversal of the caribou decline. Moose were extremely abundant in Wells Gray Park during the 1960's but forest succession in old burns that were excellent moose habitat has caused lower moose populations. The declining moose population may have resulted in fewer wolves and reduced predation on caribou compared to the 1960's when moose were abundant. Prescribed burning or wildfires that enhance moose habitat and numbers could lead to more wolves, increased predation on caribou and a further decline in the caribou population.

In summary, recent research results support the hypothesis that the colonization of southeastern British Columbia by moose in the late 1920's contributed to major declines in caribou populations by sustaining increased wolf populations and resulting in increased wolf predation on caribou. This problem is especially severe in areas where wolves, caribou and moose occupy similar areas and habitats in summer. The summer migration of most remaining caribou in Wells Gray Park results in spatial separation between caribou and wolves and consequently wolf predation on caribou is low. The current caribou population appears to be slowly increasing although some subpopulations that spend the summer in close proximity to areas used by moose and wolves may continue to decline. If the wolf predation rate continues to remain low, the caribou population could potentially increase to the much greater historic population numbers that the food resources can sustain.

MANAGEMENT RECOMMENDATIONS

HABITAT PROTECTION

1. Substantial amounts of old-growth, cedar/hemlock and mid elevation spruce/subalpine fir forest should be retained in the park to provide early winter range for caribou, especially those that spend the winter in the Cariboo Mountains. When deep snow begins to accumulate at higher elevations in early winter, these low and mid elevation forests provide reduced snow depths and arboreal lichens and shrubs for food. Priority for protection should be given to areas along the large lakes in the Cariboo Mountains, especially those areas that were heavily used by radio-collared caribou (Fig. 2). Fires in these priority areas should be suppressed.

2. Old-growth, subalpine fir/spruce forests above 1600 m in areas of gentle topography should be protected to provide late winter range. These forests provide arboreal lichens which are the primary food of the caribou throughout the winter months. Second-growth forests do not provide adequate amounts of lichen and are avoided by caribou. Both closed-canopy forests and sparsely forested habitats are used. Priority should be given to the heavily used areas identified in Figure 2.

   Fires in these forests should be suppressed. Although caribou used edges of burns and also ate lichens on surviving trees in old burns, total amount of lichen is reduced when fires destroy large areas of subalpine forest habitat.

   Some areas of subalpine forest outside of the park that were heavily used by caribou; especially in the Upper Raft River area, the plateau west of Hobson Lake and the Boss - Deception Mountain area; should be protected from logging. Young clearcuts did not appear to deter caribou movements but it is likely that dense second-growth stands would interfere with movements. Therefore, corridors should be maintained to link protected stands of old-growth habitat.

   Subalpine habitat should also be protected from disturbance by snowmobiles and aircraft (Simpson 1987). Limited disturbance by backcountry skiers is unlikely to be harmful but excessive contact should be prevented.

3. Because the wolf population is sustained primarily by moose, habitat changes that enhance moose numbers or distribution could increase wolf numbers and thereby increase the predation rate on caribou. The current caribou population appears to be increasing whereas caribou decreased when moose populations were higher. Therefore, prescribed burns to enhance moose habitat should be limited to a level necessary to maintain the current moose population but not to increase it. Also, moose habitat enhancement should be restricted to the southern end of the park around Hemp Creek to maintain the spatial separation between moose ranges and caribou summer ranges.

POPULATION MANAGEMENT

1. A regular census should be conducted to monitor changes in the caribou population over time (see Appendix A).

2. If the wolf predation rate remains low, the park could probably support a much larger caribou population. It is unclear what population size could be attained, but a population of 500 animals is a reasonable initial objective. That number of caribou should provide a viable, long-term population even if the Wells Gray population becomes isolated from surrounding populations (Franklin 1980). However, it is possible that the habitat within the park could sustain even a larger caribou population.

   Until the intial population objective of 500 caribou is attained, removals of animals by hunting or transplants should not be permitted. For purposes of reducing inbreeding, males are as important to protect as females.

3. Given the apparent interactions between caribou, wolves and moose, hunting regulations should be designed to maintain the moose population at its current level. If future census results show a decline in the caribou population and calf recruitment, wolf predation is the most probable cause, based on information from adjacent declining caribou populations (Seip 1989). A significant increase in calf survival can be expected if wolf numbers are reduced (Gasaway *et al.* 1983; Farnell and McDonald 1988).

If the population declines to less than 200 caribou, a recovery program should be initiated. Moose populations should be reduced by implementing liberal hunting seasons for cows during the winter months. Reducing the moose population should result in fewer wolves (Messier and Crete 1985) in the park and thereby reduce the predation rate on the caribou.

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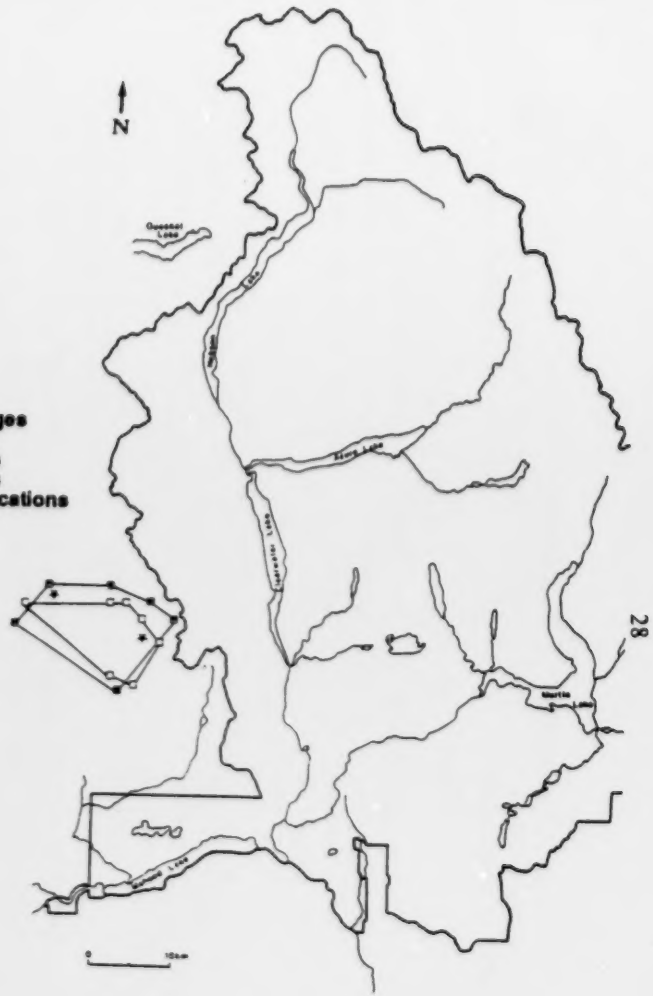
APPENDIX A. Seasonal home ranges of individual caribou that were monitored for at least one year.

"TANYA", adult female

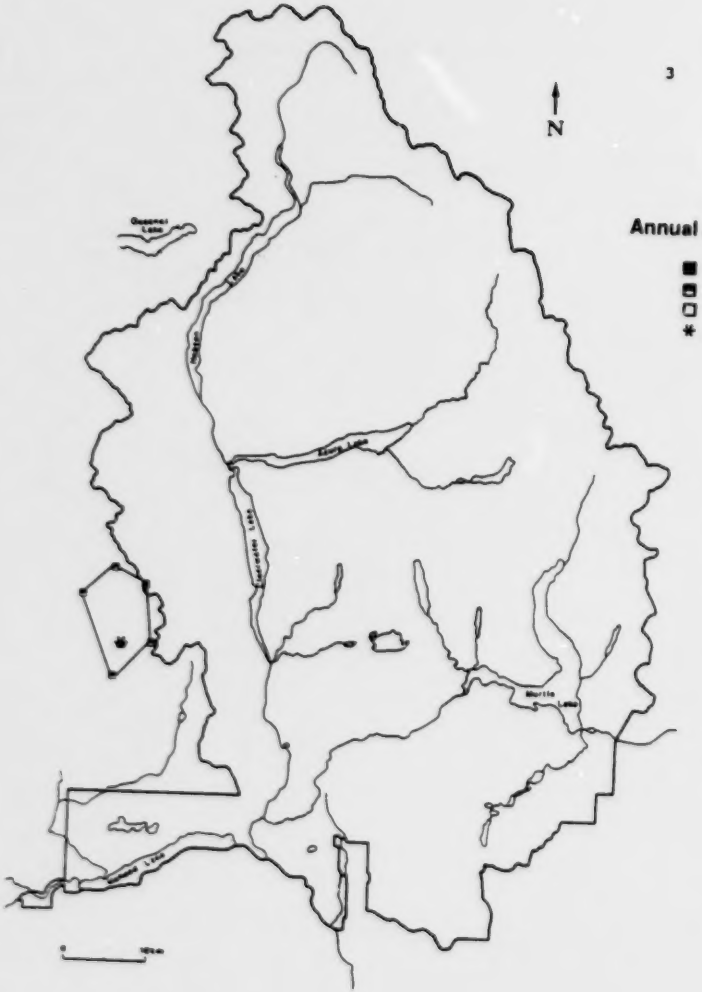
LEGEND

Annual caribou home ranges

- **1987/88 locations**
- **1988/89 locations**
- **Calving period locations**



"SHELLY", female calf (9 months) in winter 1987-88

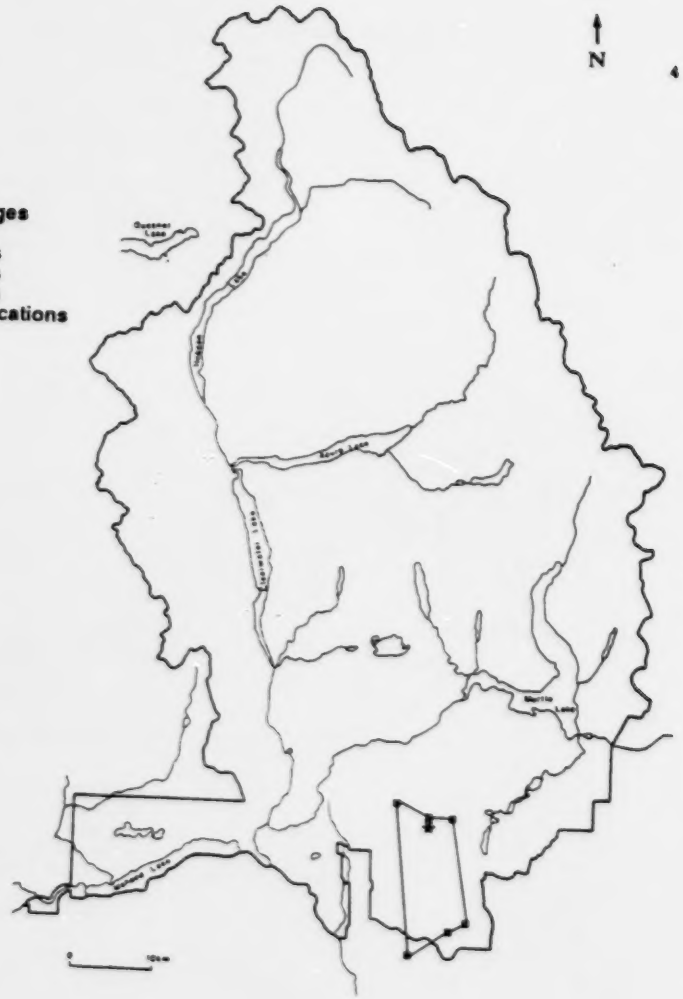


"Daphne", adult female, died summer 1988

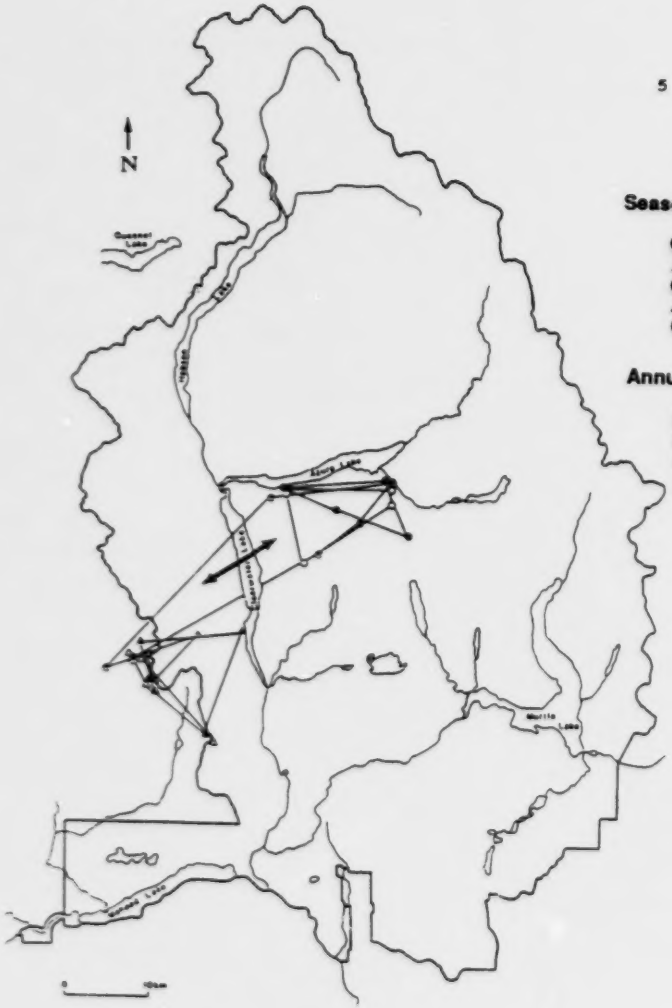
LEGEND

Annual caribou home ranges

- ■ 1986/87 locations
- ▣ 1987/88 locations
- □ 1988/89 locations
- * Calving period locations



"Katrina", adult female



5

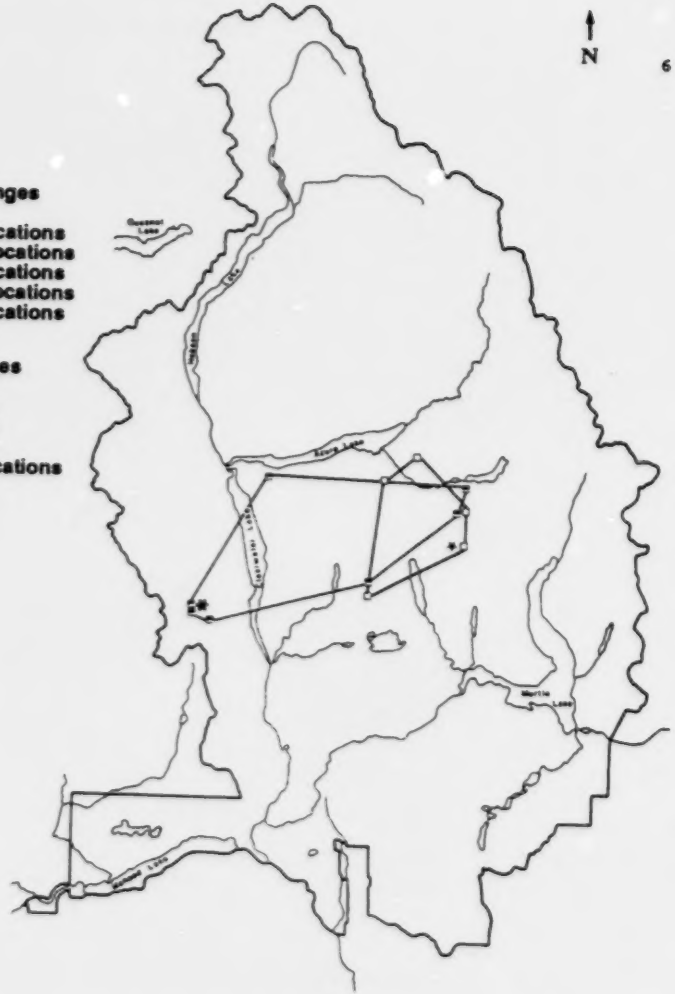
LEGEND

Seasonal caribou home ranges

- ● Summer (1986) locations
- ▲ Winter (1986/87) locations
- ◓ Summer (1987) locations
- △ Winter (1987/88) locations
- ○ Summer (1988) locations

Annual caribou home ranges

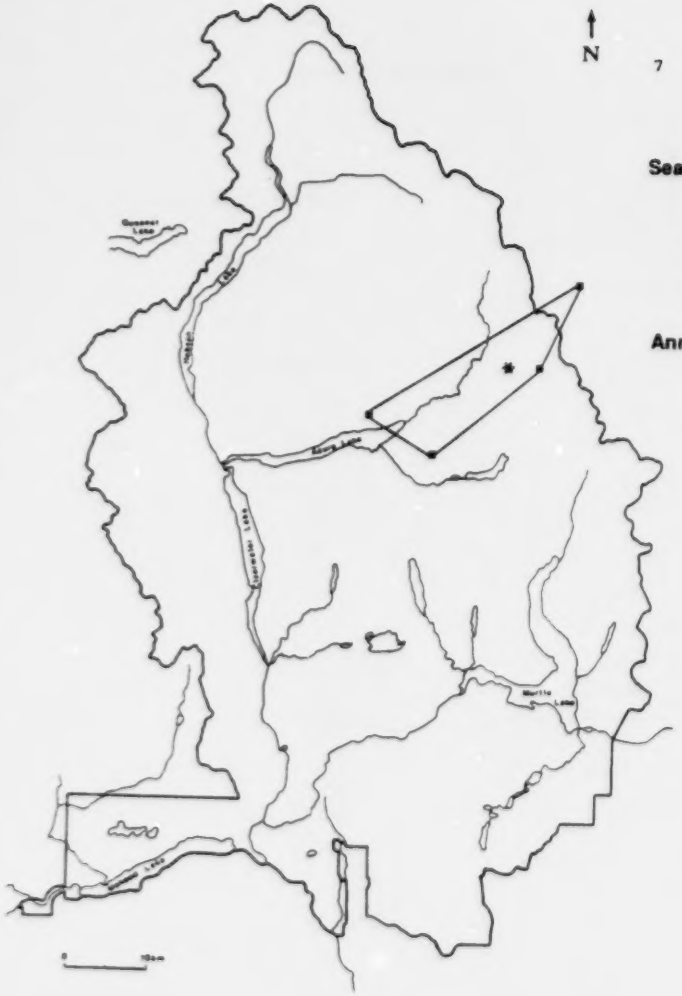
- ■ 1986/87 locations
- ■ 1987/88 locations
- □ 1988/89 locations
- * Calving period locations



6

"HARRIET", adult female

"ZELDA", adult female



LEGEND

Seasonal caribou home ranges

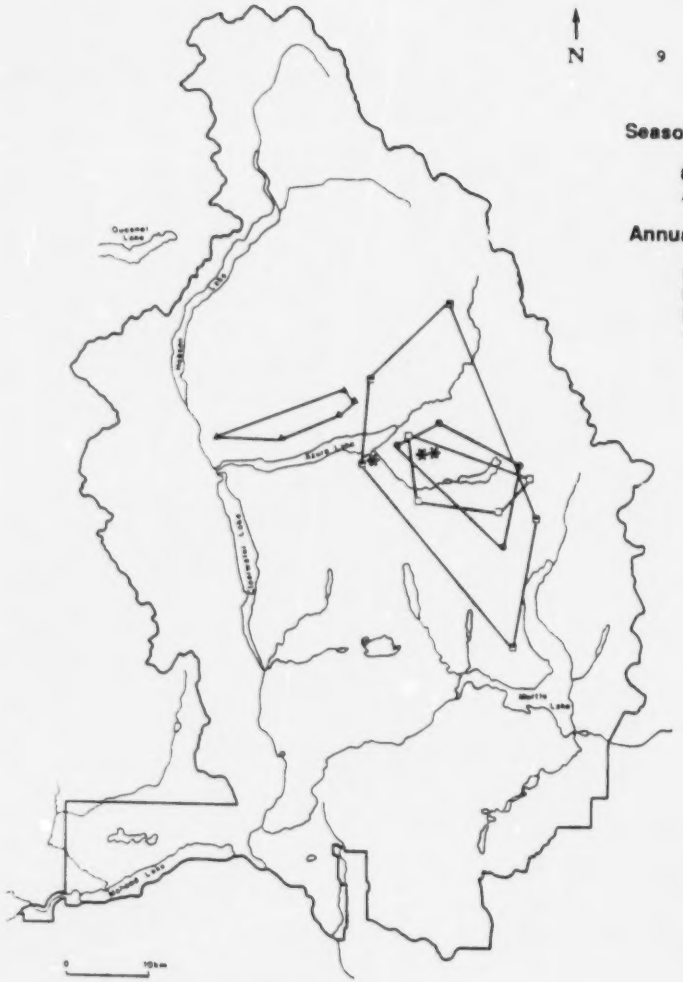
- Summer (1986) locations
- Winter (1986/87) locations
- Summer (1987) locations
- Winter (1987/88) locations
- Summer (1988) locations
- Winter (1988/89) locations

Annual caribou home ranges

- 1986/87 locations
- 1987/88 locations
- 1988/89 locations
- Calving period locations

"VIVIAN", adult female, died summer 1987

"WENDY", adult female



"URSULA", adult female

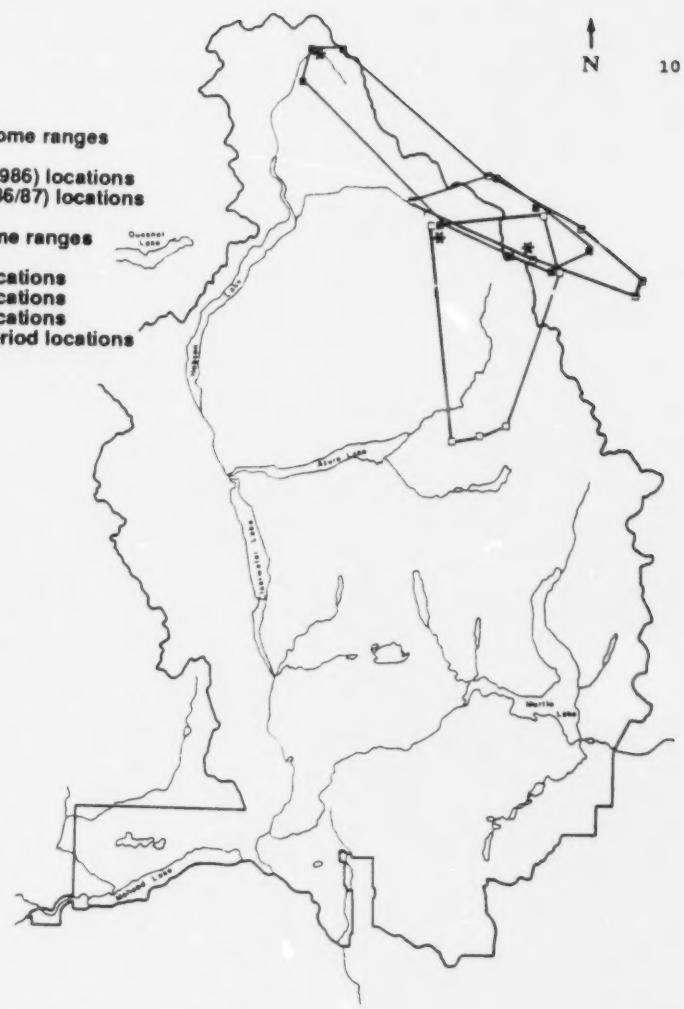
LEGEND

Seasonal caribou home ranges

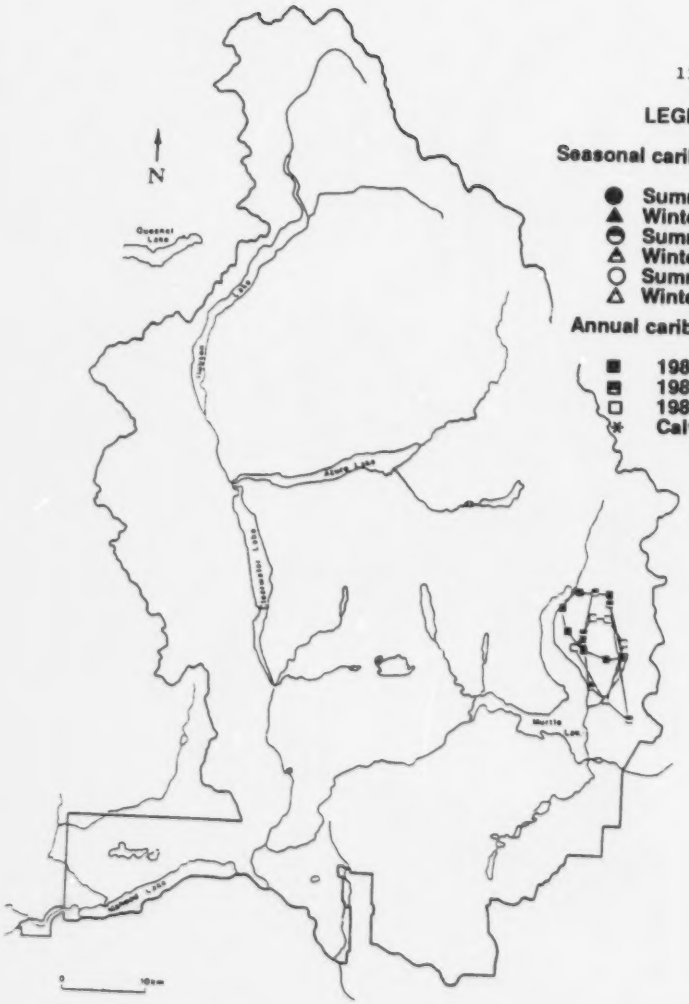
- Summer (1986) locations
- Winter (1986/87) locations

Annual caribou home ranges

- 1986/87 locations
- 1987/88 locations
- 1988/89 locations
- Calving period locations



"GERTIE", adult female



"THERESA", adult female

LEGEND

Seasonal caribou home ranges

- Summer (1986) locations
- Winter (1986/87) locations
- Summer (1987) locations
- Winter (1987/88) locations
- Summer (1988) locations
- Winter (1988/89) locations

Annual caribou home ranges

- 1986/87 locations
- 1987/88 locations
- 1988/89 locations
- Calving period locations

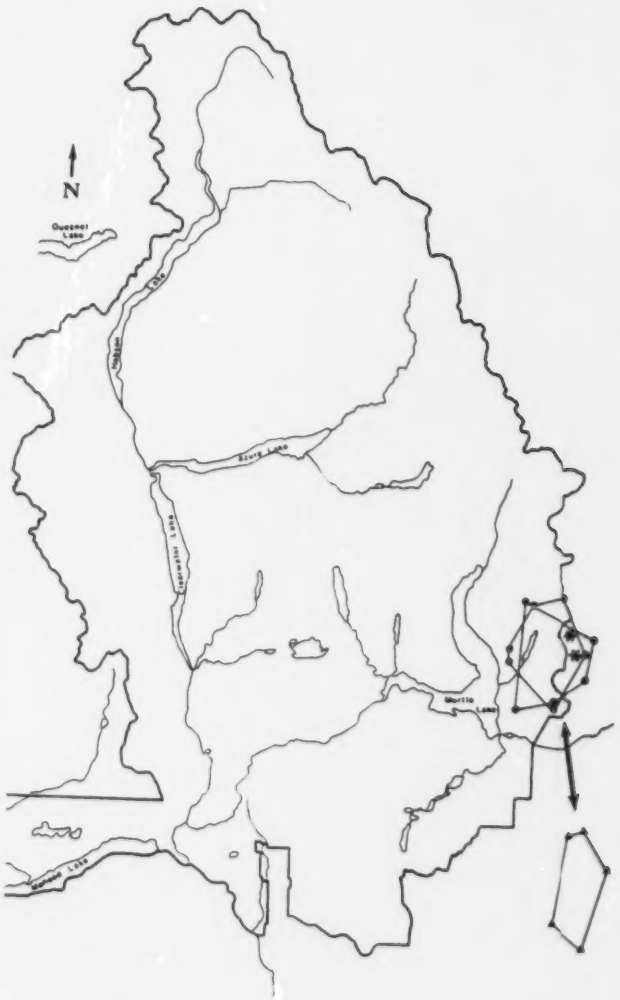
"RITA", adult female

LEGEND

Seasonal caribou home ranges

- ● Summer (1986) locations
- ▲ Winter (1986/87) locations
- ◒ Summer (1987) locations
- ◬ Winter (1987/88) locations
- ○ Summer (1988) locations
- △ Winter (1988/89) locations
- * Calving period locations

"QUESTA", adult female



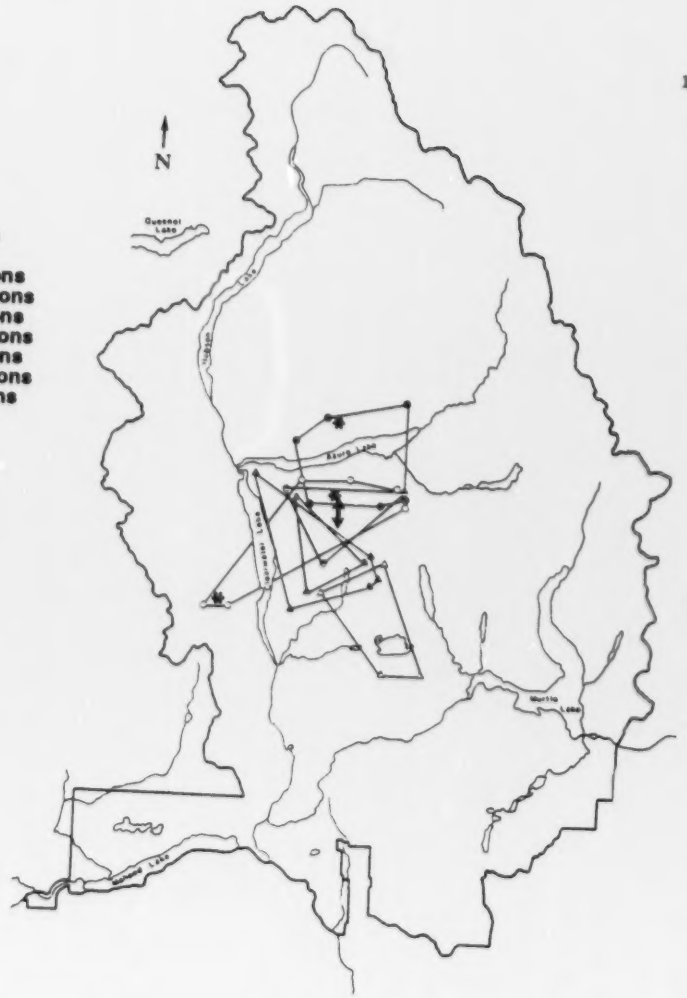
"PRICILLA", adult female, died summer 1987

"OLIVE", adult female

LEGEND

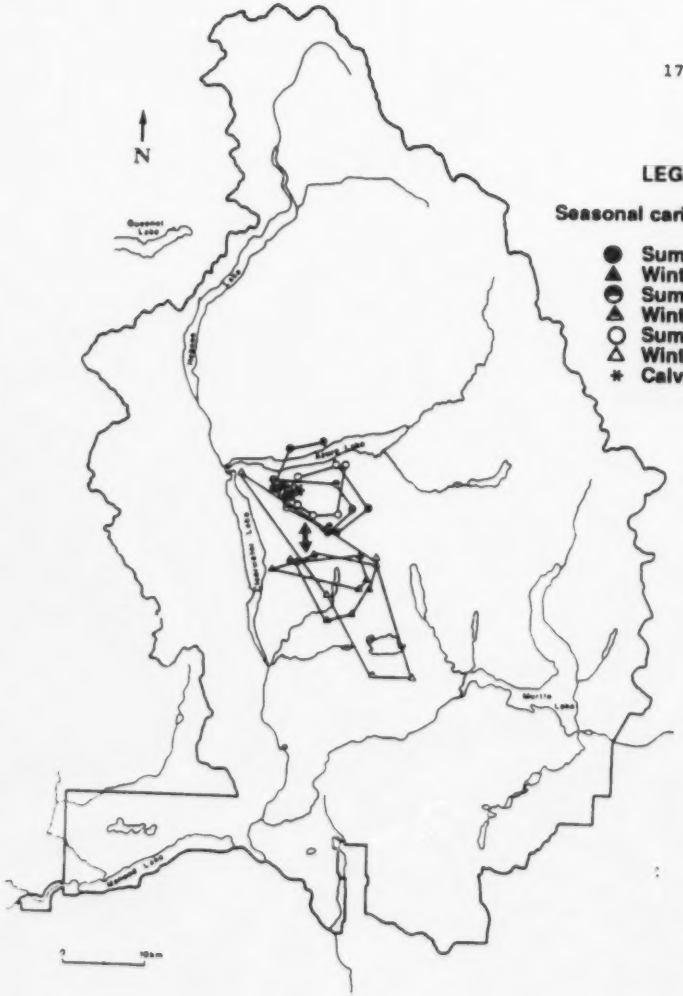
Seasonal caribou home ranges

- Summer (1986) locations
- Winter (1986/87) locations
- Summer (1987) locations
- Winter (1987/88) locations
- Summer (1988) locations
- Winter (1988/89) locations
- Calving period locations



"FAYE", adult female

17



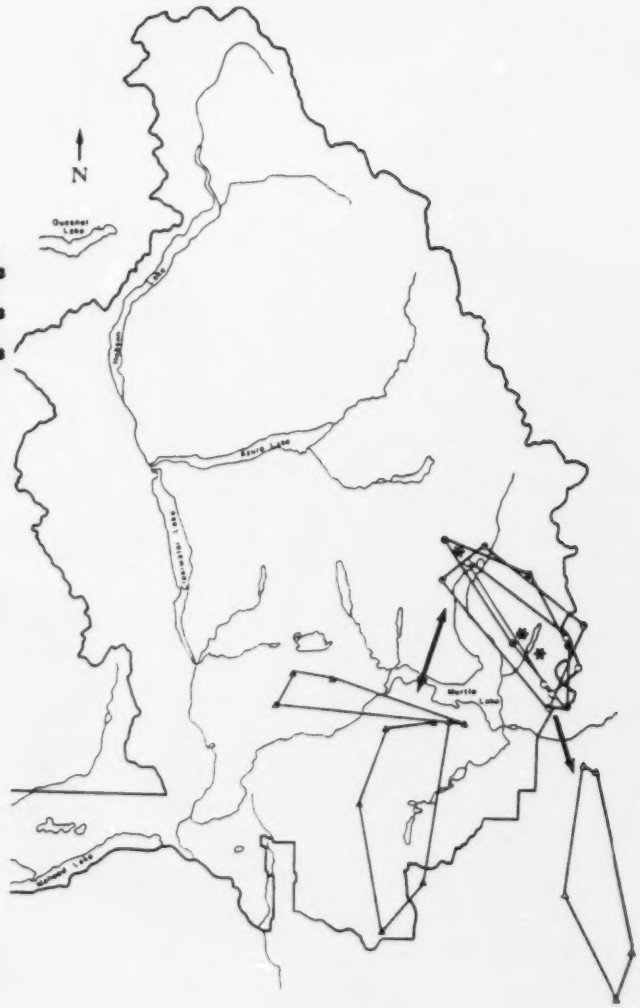
"EVELYN", adult female

18

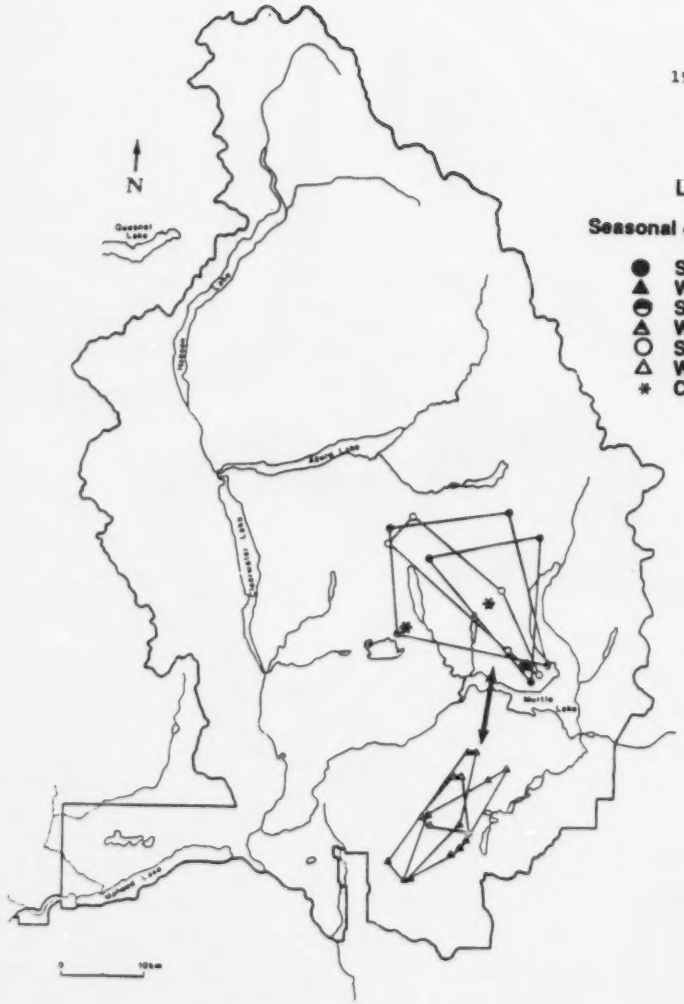
LEGEND

Seasonal caribou home ranges

- Summer (1986) locations
- Winter (1986/87) locations
- Summer (1987) locations
- Winter (1987/88) locations
- Summer (1988) locations
- Winter (1988/89) locations
- Calving period locations



"XENA", adult female

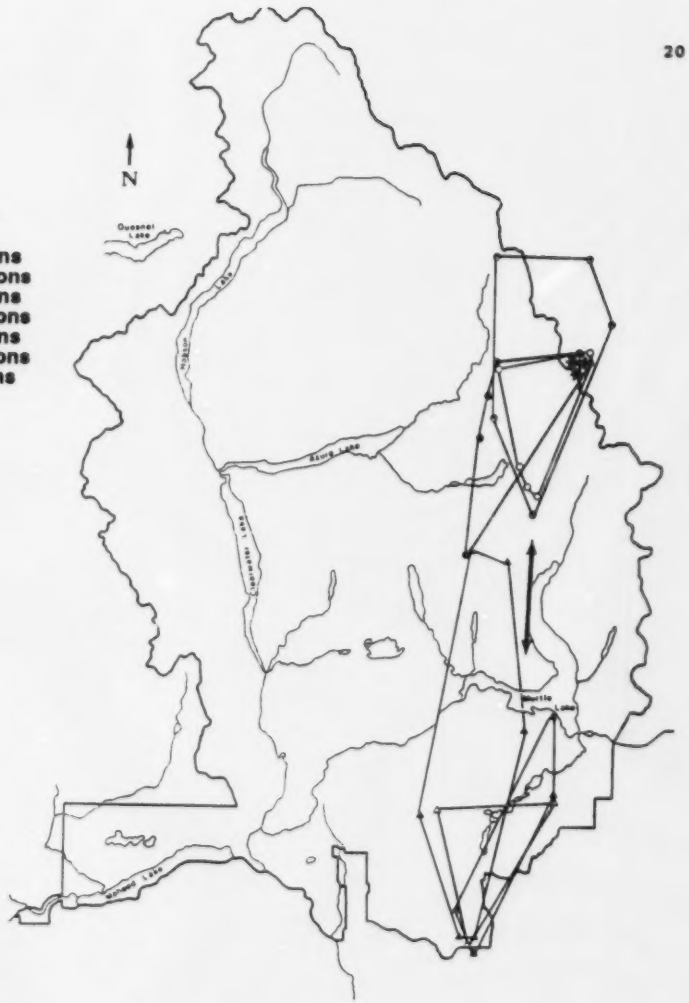


LEGEND

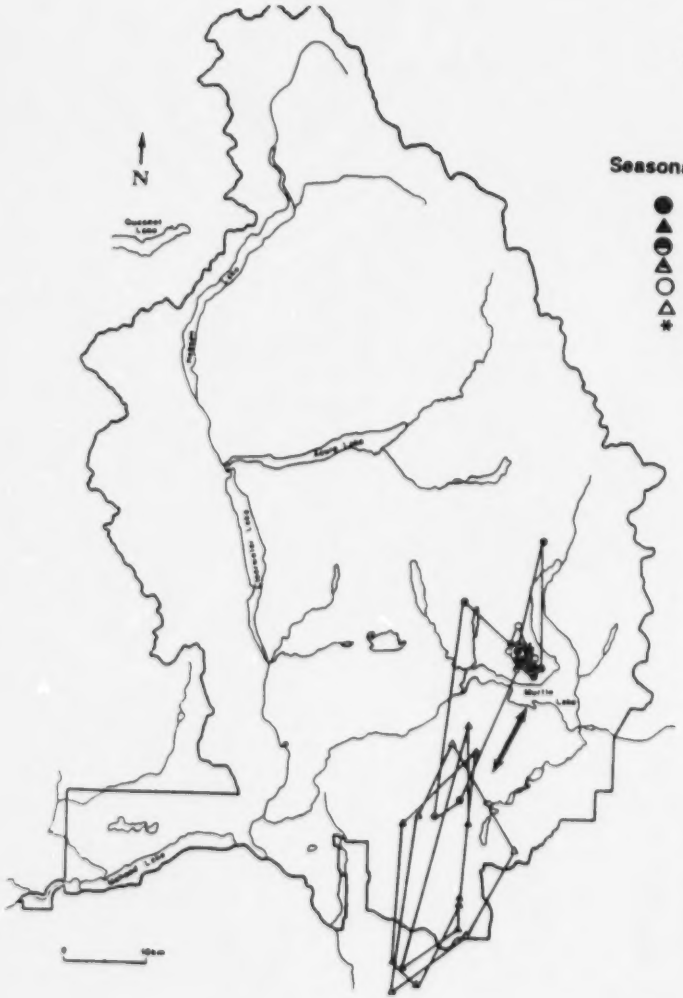
Seasonal caribou home ranges

- Summer (1986) locations
- Winter (1986/87) locations
- Summer (1987) locations
- Winter (1987/88) locations
- Summer (1988) locations
- Winter (1988/89) locations
- Calving period locations

"YVONNE", adult female



"NORMA", adult female



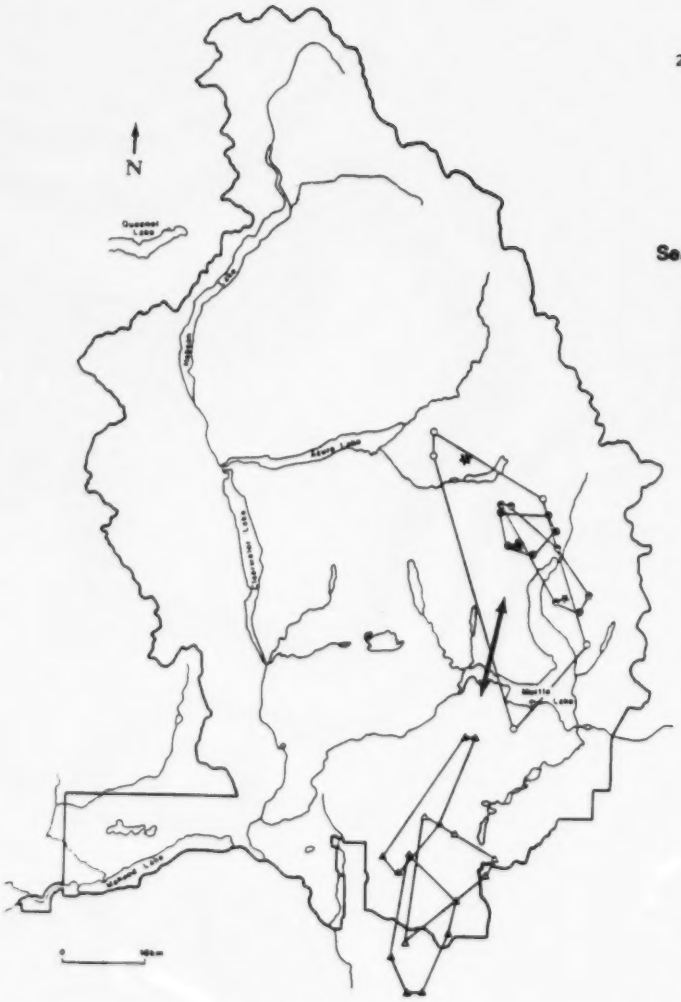
"MARY", adult female

LEGEND

Seasonal caribou home ranges

- Summer (1986) locations
- Winter (1986/87) locations
- Summer (1987) locations
- Winter (1987/88) locations
- Summer (1988) locations
- Winter (1988/89) locations
- Calving period locations

"LISA", adult female

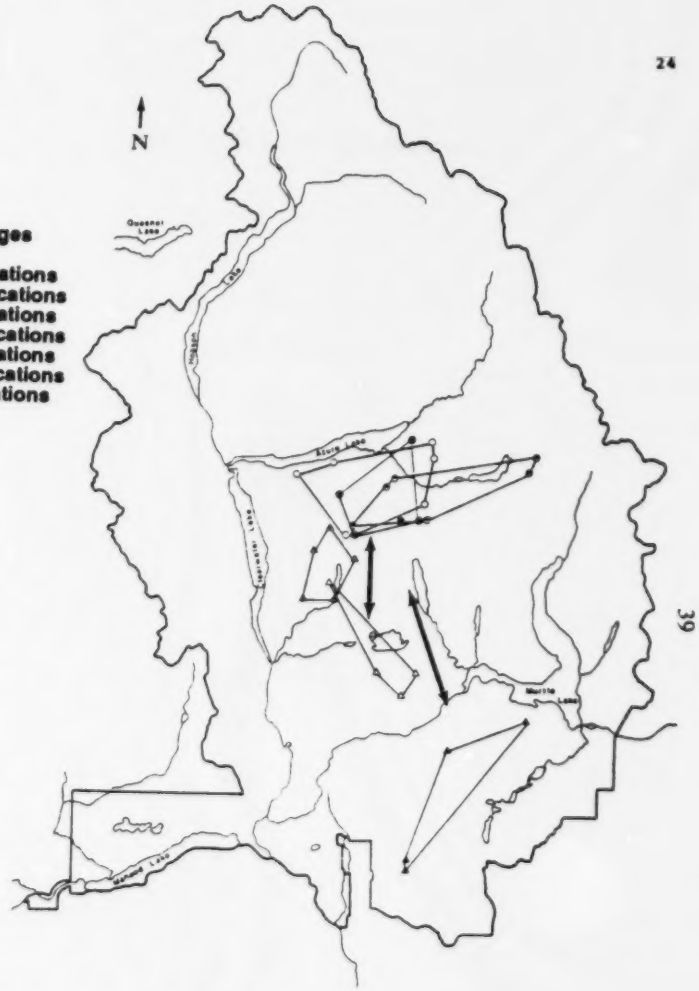


"JANET", yearling female (1.5 yrs) in winter 1985/86

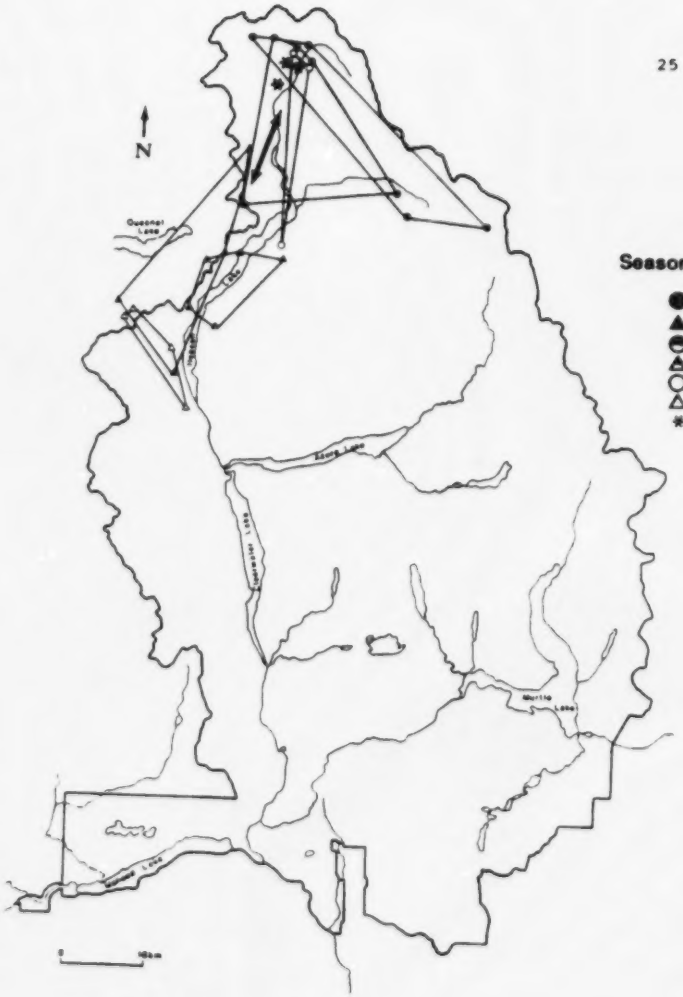
LEGEND

Seasonal caribou home ranges

- Summer (1986) locations
- Winter (1986/87) locations
- Summer (1987) locations
- Winter (1987/88) locations
- Summer (1988) locations
- Winter (1988/89) locations
- Calving period locations



"IGOR", adult male



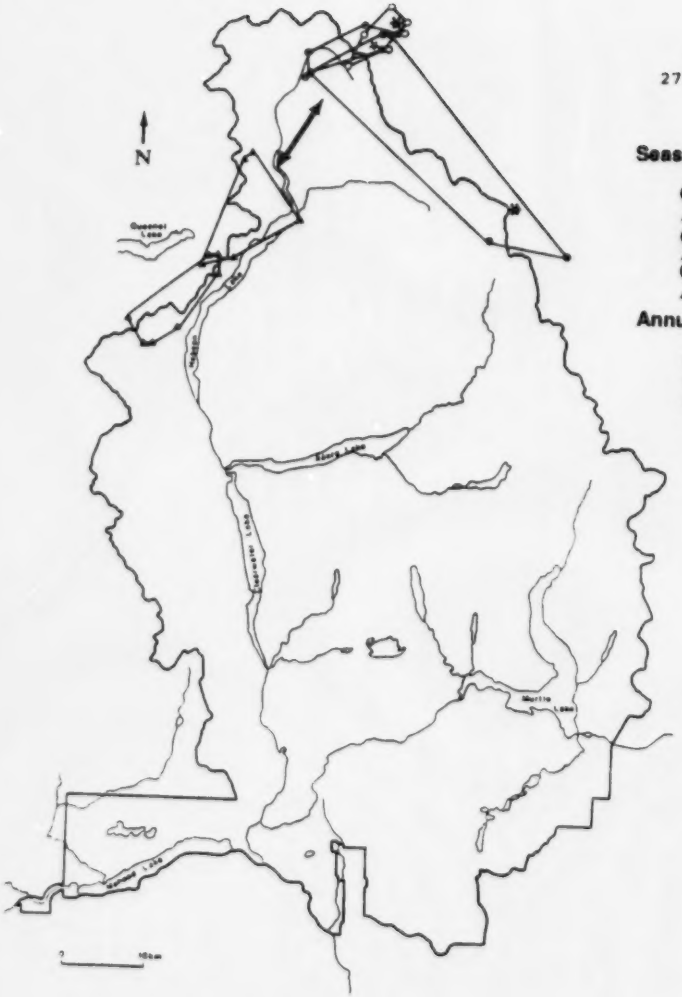
"CINDY", adult female

LEGEND

Seasonal caribou home ranges

- Summer (1986) locations
- Winter (1986/87) locations
- Summer (1987) locations
- Winter (1987/88) locations
- Summer (1988) locations
- Winter (1988/89) locations
- Calving period locations

"BONNIE", adult female, died summer 1987



27

LEGEND

Seasonal caribou home ranges

- ● Summer (1986) locations
- ▲ Winter (1986/87) locations
- ◒ Summer (1987) locations
- ◭ Winter (1987/88) locations
- ○ Summer (1988) locations
- △ Winter (1988/89) locations

Annual caribou home ranges

- ■ 1986/87 locations
- ▣ 1987/88 locations
- □ 1988/89 locations
- * Calving period locations

"ANGIE", adult female

28

"BRENDA", adult female

APPENDIX B: METHODOLOGY FOR THE MARCH HELICOPTER CENSUS OF CARIBOU

1. The census should be conducted in the last half of March or the first week of April because the greatest proportion of caribou are at high elevations in open habitat types.

2. The census should be conducted in clear, sunny weather because sightability is greatly reduced when weather conditions are poor. When weather conditions are clear, about 83% of the caribou will be seen.

3. The census should occur immediately following a major snowfall so that fresh tracks can be distinguished from old tracks. Within 2-3 days following a snowfall, caribou tracks cover extensive areas and it can be very difficult to locate the animals.

4. Areas along treeline and edges of subalpine meadow complexes on plateau areas are searched for tracks. After the tracks are located, the outer boundry of fresh tracks is determined. The area is then intensively searched to locate and count the caribou and number of calves.

5. It may not be necessary to survey the entire park every time a census is conducted. Telemetry and census results indicated that a large proportion of the park had little or no use by caribou in March (Fig. 1). Therefore, the census could be conducted more economically if only heavily used areas were censused. These areas should include:

   - Battle/Table/Trophy Mountain area,
   - Kilpill and Pillpill Mountain,
   - meadows south of Stevens Lake to the park boundary,
   - plateau southwest of Murtle Lake,
   - Murtle River drainage from Blue River top to of Ivor Creek, excluding the Murtle River above Murtle Lake,
   - Mt. Hogue area from Angus Ck. to Knutson Ck.,
   - North side of Azure Lake between Ovis Ck. and Goat Ck.,
   - West side of Hobson Lake to Lickskillet Ck.,
   - East side of Hobson Lake between DeWeis Ck. and East Ck..

   Areas adjacent to the park to census include:

   - Upper Raft River area between Stratton Ck. and Blue River,
   - North and West sides of Boss/Besig/Mica and Deception Mt..

   Those census areas within the park boundary included 90% (520/581) of all caribou counted during censuses over 3 years. The proportion varied from 86% to 92% from year to year. These priority census areas also included 86% (81/94) of all radio-collared caribou locations in March.

   If a census is conducted in late March in the priority census areas during clear weather conditions following a snowfall, the park caribou population could be estimated by:

   POPULATION ESTIMATE = TOTAL COUNT/0.9/0.83

   - where 0.9 is the correction factor for areas not censused and, 0.83 is the sightability correction factor

   Areas outside of the park in the upper Raft River and the Boss - Deception Mountain area should be counted, corrected for sightability and added on for an estimate of caribou in and adjacent to the park.

   The priority census areas could be surveyed in 5 - 6 hours of helicopter time, less than half the time required to survey the entire park. The entire survey could be completed under optimum conditions soon after a snowfall.

6. As long as the caribou population in the park remains stable or is increasing, population size could be adequately monitored by censusing every 3 years. A total park census should be conducted every 6 years with a partial census in the intervening 3 year period. However, if the population declines to less than 200 caribou, more frequent monitoring should be initiated to evaluate the effectiveness of recovery efforts. If possible, the same personel and pilot should be used for future censuses to ensure consistency of the censusing technique.

Figure B-1. Locations of radio-collared caribou in March. Numbers indicate number of locations.

Copies of Wildlife Bulletins can be obtained, depending on supply, from the Wildlife Branch, Ministry of Environment, Parliament Buildings, Victoria, B.C. V8V 1X5. Titles of Bulletins 1 to 21 are also available.

No. B-22 Landsat classification for wildlife habitat management and research planning: problem analysis. K.L. Sadoway. December 1980. 36pp. (Also printed as IWIFR-6).

No. B-23 Landsat classification: evaluation of image analysis methodologies for wildlife habitat management and research planning: working plan. K.L. Sadoway. May 1980. 29pp. (Also printed as IWIFR-7).

No. B-24 Landsat classification: evaluation of image analysis methodologies for wildlife habitat management and research planning: final report. K.L. Sadoway, ed. July 1983. 177pp. (Also printed as IWIFR-8).

No. B-25 A bibliography of the wolverine *Gulo*. V. Banci. June 1982. 53pp. (Also printed as IWIFR-9).

No. B-26 Problem analysis: grizzly bears and coastal development, with particular reference to intensive forestry. W.R. Archibald. September 1982. 24pp.

No. B-27 The wolverine in British Columbia: distribution, methods of determining age and status of *Gulo gulo vancouverensis*. V.A. Banci. June 1982. 90pp. (Also printed as IWIFR-15).

No. B-28 Vancouver Island Roosevelt elk/intensive forestry interactions: problem analysis. D. Janz, K. Brunt and J. Youds. December 1980. 36pp. (Also printed as IWIFR-11).

No. B-29 Vancouver Island Roosevelt elk/intensive forestry interactions: working plan 1981 - 1985. D. Janz, K. Brunt and J. Youds. December 1980. 60pp. (Also printed as IWIFR-12).

No. B-30 Intensive forestry effects on Vancouver Island deer and elk habitats. J.B. Nyberg. 1985. (Also printed as IWIFR-16).

No. B-31 Trees and snow: the deposition of snow on the ground. A review and quantitative synthesis. F.L. Bunnell, S. McNay and C.C. Shank. 1985. (Also printed as IWIFR-17).

No. B-32 Vancouver Island Roosevelt elk/intensive forestry interactions. October 1982 - September 1983. K. Brunt, J. Youds and D. Becker. September 1984. 67pp. (Also printed as IWIFR-13).

No. B-33 Reliability of motion-sensitiveness and radio-collars for estimating activity of blacktail deer. M.P. Gillingham and F.L. Bunnell. 1985. (IWIFR-14; printed in Journal of Wildlife Management. 1985. 49(4): 951-958).

No. B-34 Deer movement and habitat use during winter: working plan. J.B. Nyberg, D. Doyle, L. Peterson. 1985. (Also printed as IWIFR-18).

No. B-35 Forest crowns, snow interception and management of black-tailed deer winter habitat. R.S. McNay. 1985. (Also printed as IWIFR-19).

No. B-36 Comparison of methods for estimating forest overstory cover. D.J. Vales and F.L. Bunnell. 1985. (Also printed as IWIFR-20).

No. B-37 Vancouver Island Roosevelt elk/intensive forestry interactions: progress report 1981-1984. J. Youds, K. Brunt and D. Becker. 1985. (Also printed as IWIFR-21).

No. B-38 Interactions between black-tailed deer and intensive forest management: problem analysis. R.S. McNay and R. Davies. 1985. (Also printed as IWIFR-22).

No. B-39 The Vancouver Island marmot: status and management plan. W.T. Munro, D.W. Janz, V. Heinsalu and G.W. Smith. June 1985. 28pp.

No. B-40 Effects of intensive forest management on amphibians and reptiles of Vancouver Island: problem analysis. K.L. Sadoway. 1985. (Also printed as IWIFR-23).

No. B-41 Effects of intensive forest management on non-ungulate mammals of Vancouver Island: problem analysis. K.L. Sadoway. 1985. (Also printed as IWIFR-24).

No. B-42 Effects of intensive forest management on breeding birds of Vancouver Island: problem analysis. K.L. Sadoway. 1985. (Also printed as IWIFR-25).

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No. B-45 A rationale for wolf control in the management of the predator-ungulate system. D. Janz and I. Hatter. March 1986. 35pp.

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